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## STUDIES ON SOME NEMATODES OF NORTH AMERICAN FROGS. I\*

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Observations on the Nematodes parasitic in North American Frogs have been made from time to time and the results have appeared either as incidental references in papers devoted mainly to other subjects or as short papers on some special species. The same condition to a large measure is also true concerning the studies on nematodes parasitic in European and South American Amphibia. Morishita (1926) affords one of the few outstanding examples of a study of wider range, in this case devoted to the nematodes of Japanese frogs and toads. The observations contained in the present series of studies are based on materials obtained from Amphibia collected in the United States and Canada, supplemented and enlarged by the study of the large private collection of parasites from the same geographical range kindly placed at my disposal by Dr. Henry B. Ward of the University of Illinois, to whom I wish to express my appreciation for this courtesy.

This paper is confined to a study and description of nematodes parasitic in four species of North American frogs (*Rana pipiens*, *R. palustris*, *R. catesbeiana*, and *Acris gryllus*) collected from thirty-two states and also from one Province of Canada.

The following are the only eight nematode species reported from North American frogs as far as study of the literature has enabled me to determine distinct species, but the first species is very probably improperly identified, since more recent studies fail to establish *Rhabdias bufonis* as being present in these hosts:

*Rhabdias bufonis*, ex *Rana clamitans* and *R. palustris*

*Cosmocercella haberi*, ex *Hyla carolinensis*

*Oswaldocruzia leidy*, ex *Hyla carolinensis*

*Isociella quadrituberculata*, ex *Rana catesbeiana*

*Isociella solitaria*, ex *Rana pipiens*

*Physcocephalus sexalatus*, ex 'Frog'

*Agamascaris enopla*, ex *Hyla carolinensis*

*Agamascaris ontocephala*, ex *Hyla carolinensis*

The last three forms are represented only by larval stages.

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\* Contributions from the Knox College Biological Laboratories No. 32.

The species described in this paper are as follows:

Rhabdiasidae Railliet 1915

- (1) *Rhabdias ranae* n. sp. ex *Rana pipiens*, *R. palustris* and *Acris gryllus*

Trichostrongylidae Leiper 1912

Trichostrongylinae Leiper 1908

- (2) *Oswaldocruzia pipiens* n. sp. ex *Rana pipiens* and *R. palustris*

- (3) *Oswaldocruzia collaris* n. sp. ex *Rana palustris*

- (4) *Oswaldocruzia subauricularis* (Rud. 1819) ex *Rana pipiens*

Oxyuridae Cobbold 1864

Oxyurinae Hall 1916

- (5) *Pharyngodon batrachiensis* n. sp. ex *Rana pipiens* (tadpole)

Cosmocercinae Railliet 1916

- (6) *Aplectana americana* n. sp. ex *Rana pipiens*, *R. palustris* and *R. catesbeiana*

- (7) *Aplectana longicaudata* n. sp. ex *Rana pipiens*

Kathlaniidae (Travassos 1918)

Kathlaniinae Lane 1914

- (8) *Falcustra catesbeianae* n. sp. ex *Rana catesbeiana*

Filariidae (Cobbold 1864) Claus 1885

Filariinae Stiles 1907

- (9) *Foleyella ranae* n. sp. ex *Rana catesbeiana*

- (10) *Foleyella americana* n. sp. ex *Rana pipiens*

DESCRIPTION OF SPECIES

- (1) *Rhabdias ranae* n. sp. [Figs. 1-10.]

Examination of sixty-five groups of adult and twenty-one groups of larval materials of what had been supposed to be *Rhabdias bufonis* (Schränk 1788) led to the discovery that there were discrepancies in structure and life cycle which indicated a distinct specific differentiation between these North American forms and the classical European species. The adult material was collected from the lungs of forty-six specimens of *Rana pipiens* which came from various regions of the states of Illinois, Indiana, Michigan, Wisconsin, Minnesota, Iowa and North Dakota and from the Winnipeg region of Canada. In addition nineteen specimens of *Rana palustris* from Indiana and Illinois also furnished adult material of the same parasite. Twenty-one collections of larval forms were gathered from the intestines and coelomic mesenteries of ten specimens of *Rana pipiens* from Connecticut, Indiana and Illinois, from ten specimens of *Rana palustris* from Indiana and Illinois, and from a single individual of *Acris gryllus* obtained at Urbana, Illinois.

The adult nematodes ranged from 3.5 to 4.5 mm. in length and in size alone are distinctly different from specimens of *R. bufonis*, which range from 11 to 13 mm. They were fully mature as was indicated by the presence of rhabditoid embryos in the uterus. The general body measurements are as follows: Length, 3.5 to 4.5 mm.; body width at vulva, 0.3 to 0.4 mm.; nerve-ring, 0.2 to 0.3 mm. back of lips; esophagus length, 0.45 to 0.55 mm.; vulva-tail distance, 1.3 to 2.5 mm.; anus-tail distance, 0.15 to 0.25 mm.; eggs measure 40 by  $75\mu$ ; embryos at time of hatching measure 25 by  $250\mu$ . There are two pairs of post-anal lateral papillae.

The terminal circular mouth is surrounded by three low double groups of rounded papillae which overhang the infundibuliform buccal cavity. This is followed by a club-shaped esophagus. The nerve-ring is just cephalad of the mid-region of the esophagus. The intestine is dark-colored and opens through a cuticularized rectum to the anus. Three large rectal glands are present. A pair of cervical glands opening just in front of the posterior end of the esophagus extend caudad beside the intestine. The vulva opens in the posterior half of the body. The general structure of the genital apparatus is similar to that of *R. bufonis* and the five general regions can be recognized in each branch of the divergent gonads.

*Larval Development.*—The eggs usually contain embryos at the time of deposition which hatch in the lungs and upper end of the alimentary canal of the host into rhabditoid larvae with a truncated anterior end capped by a cuticularized disc. They average 30 by  $350\mu$  in size. Those found in the lower intestine of the host had increased in size until they measured 0.05 by 1.5 mm. Rudiments of the genital primordium are recognizable. The final stage in the intestinal habitat (the free-living? stage) fails to show the development into sexual males and females, as should be the case in *R. bufonis*, but appears to resemble *R. fuscovenosa* in developing directly into infective larvae. As a result of the first ecdysis a larva with a *strongyloid* type of esophagus is formed; this ensheaths, penetrates into the body cavity of the host, and eventually works into the lungs via the mesenteries before completing its life cycle. During this process ecdysis occurs at least four times, leaving the young adult surrounded by the sheaths of several of the previous molts. No examples of the last stage were found, larvae showing the third ecdysis being the oldest material available. The measurements of the strongyloid larvae averaged as follows: Length, 2 to 3.83 mm.; width in mid-body, 45 to  $90\mu$ ; esophagus slightly claviform and 200 to  $400\mu$  in length; nerve-ring, 125 to  $165\mu$  from lips; anus-tail distance, 50 to  $165\mu$ ; sex-rudiments double; vulvar region posterior to middle of body; distinct cervical glands present. The ensheathed larvae from the coelom



averaged 2.17 to 4.5 mm. in length; 75 to 105 $\mu$  in greatest width; the esophagus measured 345 to 450 $\mu$ ; the nerve-ring 200 to 260 $\mu$  from the lips; anus-tail distance, 150 to 225 $\mu$ ; vulvar region in the posterior half of the body. Sex-rudiments are well indicated as also are the large cervical glands. The buccal capsule of the sheath resulting from the third ecdysis shows six small lip papillae and is sub-cylindrical in shape. The contained larva shows a buccal capsule with a thickened cuticular rim characteristic of the provisional buccal capsule of the fourth stage in the life cycle of other members of this genus. The tail is conical but not nearly as sharply so as is that of the previous stage larva. The fourth stage larva is comparable in size with the adult worm which undoubtedly develops as a result of the fourth ecdysis. These young adults finally emerge from their surrounding sheaths to complete the life cycle after final penetration of the lung tissue of the host.

Based upon the morphological and biological differences between this form and *Rhabdias bufonis* (Schrank 1788) it seems necessary to separate the two into distinct species. Since the present description applies to material coming from a rather wide area in Temperate North America and also differs materially from specimens obtained from the toads of the same region, the new species has been designated as *Rhabdias ranae* n. sp.

Type material is in the collection of Dr. H. B. Ward, University of Illinois.

(2) *Oswaldocruzia pipiens* n. sp. (Fig. 11-15.)

A large number of both sexes of an apparently undescribed species of *Oswaldocruzia* were obtained from the small intestine of eleven examples of *Rana pipiens* and from five of *Rana palustris*, coming from Wisconsin, Minnesota and Illinois. These forms varied distinctly from *O. leidyi* Travassos 1917 as reported by Steiner (1924) apparently being more closely related to *O. filiformis* (Goeze) Trav. 1917 than to *O. subauricularis* (Rud.) Trav. 1917.

The body is characterized by the presence of vesicular head swellings covered by distinct annulations and by the presence of two distinct lateral cervical alae, thus causing it to belong to the subgenus *Bialata* (Morishita 1926) along with *O. bialata*, *O. socialis*, *O. yezoensis*, and *O. subventricosa*. The general body shows faint longitudinal ridges, about forty-five in number, in the mid-body region. Both sexes taper gradually cephalad from a cylindrical midbody region and the female does so caudad, ending in a distinct spike. The male shows no such taper in front of the bursa. The head shows four small sub-median papillae, as well as paired amphids. The three lips surround the small cuticularized opening of the cylindroconical esophagus which shows a distinct posterior swelling. Cervical papillae and excretory pore are midway between the nerve-ring and the posterior end of the esophagus.

The *males* average 10.5 mm. in length and 0.132 mm. in greatest width. The nerve-ring encircles the esophagus 0.2 to 0.25 mm. from the lips. The esophagus measures 0.45 to 0.48 mm. in length. The cloaca opens 0.16 to 0.2 mm. in front of the tip of the dorsal lobe of the bursa. The complicated spicules average 0.225 mm. in length. The bursa is distinctly tri-lobed. The bursal rays are as shown in the figures. The dorsal ray terminates in four branches, the inner pair of which are again bifurcated. This arrangement alone differentiates this species from the others in the same sub-genus and to some extent from any known member of the entire genus.

The *females* average in measurements as follows: Length, 15.7 mm.; width at vulva, 0.15 mm.; nerve-ring is 0.225 mm. from the lips; length of esophagus, 0.57 mm.; vulva-anus distance, 6.1 mm.; anus-tail distance, 0.3 mm.; eggs in morula stage measure, 35 by 60 $\mu$ . The vulva is slightly sunken below the general body surface and opens into short 'amphidelph' ovejector vestibules. These in turn open through shell-glands and a muscular funnel into the uteri.

Resembling *O. leidyi* and *O. insulae* in the possession of longitudinal cuticular ridges and short, straight ovejectors, this species differs greatly in size, possession of distinct cervical alae, and decidedly different dorsal ray pattern. Size and dorsal ray pattern as well as those characteristics held in common with *O. leidyi*, separates this species from the other known North America species, *O. subauricularis* and *O. collaris*. It resembles *O. filiformis* in general size but differs in dorsal ray pattern, relative position of vulva and the form of the ovejector, size of eggs, the much shorter tail of the female, a different spicule pattern, in the possession of longitudinal ridges in the cuticula and particularly through the presence of cervical alae.

The species has been designated as *Oswaldocruzia pipiens* n. sp., with the type host *Rana pipiens* and the type locality Illinois. Other host: *Rana palustris*. Geographical distribution thus far determined as Wisconsin, Illinois and Minnesota. (A single example labelled as coming from the stomach of *Leptodactylus* sp?, Kartabo, South America, apparently belongs to this new species and may indicate a very much wider variety of hosts and greater range of distribution than is now realized.)

Type material is in the collection of Dr. H. B. Ward, University of Illinois.

(3) *Oswaldocruzia collaris* n. sp. (Figs. 16-18.)

Female specimens of a species of *Oswaldocruzia* obtained from the intestine of *Rana palustris* at Urbana, Illinois, do not agree with the descriptions of either *O. leidyi* or *O. pipiens* and serve as the type of a third North American species of this genus; *Oswaldocruzia collaris*



n. sp., so named because of the prominent collar-like vesicle in the inflated head region. Size and general body proportions as well as absence of longitudinal cuticular ridges and cervical alae separate this form from either of the above species. It is placed in the sub-genus *Oswaldocruzia* (Morishita 1926). Unfortunately only the females are as yet known.

The general body measurements are as follows: Length, 10.75 mm.; width at vulva, 0.135 mm.; nerve-ring, 0.185 mm. back of lips; length of esophagus, 0.4 mm.; vulva-tail distance, 3.8 mm.; anus-tail distance, 0.18 mm. plus 0.015 mm. of terminal spike; paired ovejectors, 0.15 mm. in length; shell glands, 0.055 mm. in diameter; muscular funnel, 0.08 mm. long; eggs measure 30 by 60 $\mu$  and contain larvae at time of oviposition. Three well defined lip-like structures and four sub-median papillae as well as paired amphids surround the mouth. Well defined anal musculature is present as well as three distinct rectal glands. The vesicular "collar" is about 15 $\mu$  back of the tip of the body. Distinct annulations extend posteriad 60 to 70 $\mu$ . Cervical alae and longitudinal cuticular ridges are apparently absent. Cervical papillae and excretory opening are found shortly in front of the intestino-esophageal junction.

Type material is in the collection of Dr. H. B. Ward, University of Illinois.

- (4) *Oswaldocruzia subauricularis* (Rud. 1819) Travassos 1917.  
(Figs. 19-27.)

Several female specimens were found among examples of *O. pipiens* which answer better to the descriptions of *O. subauricularis* than to that of *O. pipiens* and seems to indicate the possibility of the former species extending its range over the whole of the American Continent instead of being confined to South America as has been apparently the case thus far.

The specimens lack the cephalic wings and longitudinal cuticular striations of *O. pipiens* and also show a longer 'S'-shaped ovejector. The general measurements are as follows: Length, 8.5 to 10.2 mm.; width at vulva, 0.2 to 0.25 mm.; esophagus length, 0.5 to 0.56 mm.; nerve-ring, 0.26 to 0.28 mm. back of the lips; lips indistinct; submedian papillae and amphids present; excretory pore and cervical papillae just behind the nerve-ring (0.29 to 0.31 mm.); vulva-tail distance, 3.1 to 3.3 mm.; anus-tail distance, 0.175 to 0.2 mm.; morulated eggs measure 50 by 90 $\mu$ .

From *Rana pipiens*, Illinois.

- (5) *Pharyngodon batrachiensis* n. sp. (Figs. 22, 23.)

A large number of female Oxyurids obtained from the intestine of tadpoles of *Rana pipiens* (ex Douglas Lake, Mich.) belong to an

undescribed species of the genus *Pharyngodon* and affords a definite example of the presence of a member of this genus in Amphibia; the other species all having been reported from lizards.

The body is stout and short, tapering abruptly at the posterior end to a long naked spike-like tail. The anterior end shows distinct annulations which become indistinct caudad. Lateral flanges are indistinct or absent. The mouth is surrounded by three indistinct lips. No buccal cavity or vestibule is present. The esophagus shows a prominent posterior bulb separated by a distinct constriction. The excretory pore, contrary to the conditions in the other species of the genus, is opposite the esophageal bulb instead of being more posteriorly placed. The vulva is much farther from the excretory pore than common for the genus, but still is characteristically in the anterior half of the body. A distinct vagina gives rise to the coiled uteri which occupy most of the body space of the mature adult. The eggs are a much flattened ovoid and show distinct terminal plugs. This species is oviparous, the eggs showing no signs of segmentation when oviposited.

The general measurements are as follows: Length, 4.2 mm.; width at vulva, 0.365 mm.; length of esophagus, excluding bulb, is 0.56 mm.; diameter of bulb is 0.125 by 0.15 mm.; nerve-ring is 0.165 mm. from the lips; excretory pore is 0.61 mm. from the lips; vulva-head distance is 1.8 mm.; anus-tail distance (including spike) is 0.9 mm.; spike is 0.76 mm. in length; the eggs measure 35 by 100 $\mu$  and are surrounded by a double membrane, the inner one of which shows the terminal plugs.

Type specimens are in the collection of Dr. H. B. Ward, University of Illinois.

(6) *Aplectana americana* n. sp. (Figs. 24-27.)

A fairly common parasite from the cecal regions of *Rana pipiens*, *R. palustris*, and *R. catesbeiana* belongs to the genus *Aplectana* and to a hitherto undescribed species, *A. americana* n. sp. The body is short and stout, tapering gradually cephalad and rather abruptly caudad in both sexes. The three lips are low and each has two small papillae. Three small cuticular teeth are at the base of the buccal cavity. A short muscular pharynx is followed by a longer esophagus which terminates in a sharply differentiated vase-like bulbar region possessing distinct cutting plates. The excretory pore is opposite the neck region of the bulb. The male has the posterior end bent sharply ventrad. There are five pairs of pre-anal, one pair of ad-anal, and five pairs of post-anal sessile papillae. The spicules are sub-equal, simple and relatively short. A well developed accessory piece is present. The posterior end of the female is abruptly conical and sharply pointed. This species is oviparous, the eggs being in the early morula stage when oviposited.



The average measurements of the species are as follows:

*Male*.—Body length, 2.4 mm.; greatest width, 0.15 mm.; length of pharynx, 0.035 mm.; length of esophagus, excluding bulb, 0.315 mm.; bulb, 0.08 by 0.085 mm.; nerve-ring is 0.015 mm. from the lips; excretory pore is 0.35 mm. from the lips; cloaca-tail distance is 0.14 mm.; the spicules measure 0.155 mm.; and the accessory piece measures 0.072 mm. in length.

*Female*.—Body length, 4.05 mm.; width at vulva, 0.27 mm.; length of pharynx, 0.045 mm.; length of esophagus, excluding bulb, 0.34 mm.; bulb, 0.112 by 0.12 mm.; nerve-ring is 0.27 mm. from the lips and excretory pore 0.39 mm.; vulva-anus distance is 1.9 mm.; and the anus-tail distance is 0.21 mm.

This species was found in frogs taken in the Mississippi basin, ranging from Wisconsin south to Louisiana.

Type material is in the collection of Dr. H. B. Ward, University of Illinois.

(7) *Aplectana longicaudata* n. sp. (Figs. 28-30.)

Other specimens of *Aplectana* were also taken from the intestine of *Rana pipiens* which differed so materially from *A. americana* that they form the basis of a new species, *A. longicaudata* n. sp. They are relatively small and slender forms showing distinct lips, each with two prominent papillae but no definite teeth, and ending in long slender tails. The pharyngeal region is poorly differentiated. The excretory pore is opposite the middle of the esophageal bulb. The spicules are short and slender and the accessory piece is very small. There are five pairs of pre-anal and six pairs of post-anal sessile papillae. The vulva is practically in the middle of the body or slightly cephalad. The eggs are small and apparently are unsegmented when they reach the vagina.

The average measurements are as follows:

*Male*.—Body length, 2.28 mm.; greatest width, 0.11 mm.; length of pharynx and esophagus, excluding bulbar region, 0.37 mm.; diameter of bulb, 0.058 by 0.068 mm.; nerve-ring, 0.15 mm. back of the lips; opening of the excretory duct, 0.4 mm. from the lips; anus-tail distance is 0.233 mm.; spicule length is 0.15 mm.; and accessory piece measures 0.036 mm. in length.

*Female*.—Body length, 3 to 4 mm.; width at vulva, 0.185 mm.; length of pharynx and esophagus, excluding bulbar region, 0.397 mm.; diameter of bulb, 0.06 by 0.075 mm.; nerve-ring, 0.245 mm. back of the lips; excretory pore opens 0.425 mm. back of the lips; vulva-anus distance is 1.7 to 2 mm.; and the anus-tail distance is 0.45 mm.

This species has been obtained only from hosts collected in Illinois.

Type material is in the collection of Dr. H. B. Ward, University of Illinois.



(8) *Falcustra catesbeianae* n. sp. (Figs. 31-36.)

The most common intestinal nematode of the Bullfrog is a species of *Falcustra* (= *Spironoura*?) which up to this time has apparently been undescribed. Because of its specificity of host and its wide geographical distribution this parasite is here designated as *F. catesbeiane* n. sp. This is also apparently the first record of any species of this genus appearing in Amphibia, the usual hosts being tortoises, snakes and fresh-water fishes.

This species is short and relatively slender in body form; has a three lipped mouth, each lip bearing two large external and two smaller tooth-like internal papillae; has a smooth cuticula lacking any longitudinal ridges or wings; has a short vestibule, the anterior end of which is supported by a chitinous ring; has a heavily cuticularized lining to the muscular pharynx which is tipped by three chitinous cutting plates; has a long muscular esophagus terminating in a distinctly double bulb, each portion of which shows cuticularized grinding surfaces; and has a three-lobed cuticularized cardia. The tail in both sexes tapers to a sharply pointed tip. The male has the pre-cloacal musculature specialized to form a single sucker-like organ; has very rudimentary post-cloacal caudal alae; has three pairs of pre-cloacal and seven pairs of post-cloacal papillae, two of the post-cloacal papillae being lateral in position and supporting the rudimentary caudal alae; has a median double pre-cloacal papilla; has short thin sickle-shaped and broadly alate spicules; and a well defined accessory piece. The vulva is in the anterior half of the body not far from the mid-region; the vagina passes dorsad and cephalad before dividing into the two opposed branches of the ovejector; and the eggs are non-segmented at oviposition, hence this species is oviparous.

*Male*.—Body length, 3.5 to 4 mm.; greatest width, 0.175 to 0.2 mm.; length of pharynx, 0.075 to 0.08 mm.; length of esophagus and anterior bulb, 0.7 to 0.75 mm.; diameter of posterior bulb, 0.1 by 0.14 mm.; nerve-ring is 0.25 to 0.275 mm. from the lips; cloacal-tail distance is 0.35 mm.; sucker-like organ is 0.7 to 0.9 mm. in front of the cloaca; and the spicules measure 0.3 to 0.325 mm.

*Female*.—Body length, 4 to 4.5 mm.; width at vulva, 0.225 to 0.25 mm.; length of pharynx, 0.075 to 0.08 mm.; length of esophagus and anterior bulb, 0.8 to 0.85 mm.; diameter of posterior bulb, 0.15 by 0.18 mm.; nerve-ring is 0.3 to 0.325 mm. from the lips; vulva-anus distance is 1.6 to 1.7 mm.; anus-tail distance is 0.35 to 0.4 mm.; and unsegmented eggs measure 60 by 75 $\mu$ .

The geographical range thus far established is Illinois, Oklahoma and Louisiana.

Type material is in the collection of Dr. H. B. Ward, University of Illinois.

(9) *Foleyella ranae* n. sp. (Figs. 37-41.)

The first record of the occurrence of a species of the genus *Foleyella* in any of the frogs, as well as the first North American report of any species of this genus, is afforded by the finding of several examples of both sexes of a new species, *Foleyella ranae* n. sp., encysted in the mesenteries of a Louisiana Bullfrog, *Rana catesbeiana*.

This form from the Frog is somewhat aberrant in comparison with the forms reported from toads and reptiles but these differences do not seem to justify greater than specific differentiation. The general body form is short and fairly stout and is marked by broad, light-colored lateral fields and narrow lateral alae extending the whole length of the body. The mouth is surrounded by two circles of papillae, an inner group of six small papillae and an outer group of four more conspicuous papillae. The two-parted esophagus is relatively longer than is usual in the genus, extending up to  $\frac{1}{8}$  th of the body length in the males and to  $\frac{1}{11}$  th in the females. The nerve-ring encircles the posterior end of the anterior part of the esophagus. The rectum, usually very long in this genus, is very short and stout in the female and only slightly longer and narrower in the male. The tail of the male shows well-developed caudal alae supported by six pairs of pedunculated and one pair (possibly two pairs) of sessile papillae. Four pairs are post-anal and three pairs are pre-anal, the sessile pair being the most anterior. This condition is the reverse of the common pattern, i. e., four pre-anal and three post-anal pairs of papillae. The slight medial pre-cloacal swelling is not deserving the term papilla since it seems to lack the 'core' characteristic of true papillae. The spicules are very unequal, the right being short and broadly alate while the left is long, narrow and very twisted. The testis is in the esophageal region and the coiled goniducts practically occlude the body cavity in a manner resembling the condition found in the female. No accessory piece is present. The vulva is about opposite the mid-region of the posterior portion of the esophagus. The vaginal tube passes cephalad and coils intricately before turning caudad and at the level of the anterior portion of the intestine gives rise to the uterine tubes. These extend into the posterior half of the body before separating to eventually reach the 'amphidelph' ovaries. This form is viviparous, well-developed embryos being present in the uterus. The posterior end of the female shows three terminal pedunculate papillae supporting that portion of the lateral alae.

*Male*.—Body length, 8.7 mm.; greatest width, 0.23 mm.; length of the anterior esophagus, 0.165 mm.; length of the posterior esophagus, 0.975 mm.; nerve-ring is 0.15 mm. behind the mouth; cloaca-tail dis-



tance, 0.09 to 0.1 mm.; length of right spicule, 0.113 mm.; and that of the left 0.35 mm.

*Female*.—Body length, 16.5 mm.; width at vulva, 0.4 mm.; length of the anterior esophagus, 0.265 mm.; length of the posterior esophagus, 1.23 mm.; nerve-ring is 0.23 mm. behind the mouth; mouth-vulva distance, 1.1 mm.; and the anus-tail distance, 0.15 mm.

Type material is in the collection of Dr. H. B. Ward, University of Illinois.

(10) *Foleyella americana* n. sp. (Figs. 42, 43.)

Females of a much more typical species of *Foleyella* were obtained from cysts in the mesenteries of specimens of *Rana pipiens* taken in Illinois. The body is long and slender, showing the characteristic conspicuous lateral fields and also the continuous lateral flange extending from one side of the mouth the entire length of the body, around the tail where it is supported by three terminal papillae, and back to the other side of the mouth-opening without a break. The mouth is surrounded by ten papillae in two circles, the inner of six and the outer of four members. The vulva is post-esophageal. The extremely long vagina and ovejector passes almost to the anterior esophagus before turning caudad and eventually dividing into the opposed uterine tubes. The eggs are embryonated in the lower regions of the uteri. The two-parted esophagus is characteristically short but the rectum, though very narrow, is very short for a member of this genus. The name *Foleyella americana* n. sp. has been given to this form since, though the males are as yet unknown, there can be no doubt as to the generic position of the worms and the females differ very widely in characters of specific value from those of any of the previously known species of *Foleyella*. This record adds a second species to the list of North American parasites of Amphibia which belongs to the genus *Foleyella*.

*Female*.—Body length, 50 mm.; width at vulva, 0.66 mm.; length of the anterior esophagus, 0.265 mm.; length of the posterior esophagus, 1.16 mm.; nerve-ring is 0.2 mm. behind the mouth; mouth-vulva distance, 1.8 mm.; length of ovejector, 11 mm.; embryonated eggs measure 18 by 25 $\mu$ ; length of rectum is 0.25 mm.; and the anus-tail distance is 0.26 mm.

Type material is in the collection of Dr. H. B. Ward, University of Illinois.

#### SUMMARY

This study has added ten species, belonging to six genera, to the list of eight species in six genera already reported from North American Frogs. Nine of these added species are new and the tenth is new to North America. The life history of a new form of *Rhabdias* has been

worked out. The prevalence of this species in North American Frogs seems to indicate that the European *R. bufonis* is probably not present here and that individuals of *R. ranæ*, or other similar species of Rhabdias, have been erroneously reported as being examples of *R. bufonis*. The genus *Foleyella* is for the first time recorded from frogs and also for North America and is represented by two species. The genus *Falcustra* (= *Spironoura*?) is likewise for the first time reported from frogs, or any other Amphibian. The genus *Pharyngodon* is also reported as being a new parasite of an Amphibian host, normally being found in Lizards. The genus *Oswaldocruzia* received two new species, making four members of this genus now known from North American frogs. One of these new species, *O. pipiens*, is also reported from South American hosts, indicating a wide geographical distribution. *O. subauricularis*, a South American form, is reported from North American hosts. Two new species of *Aplectana* are also added. This genus has not heretofore been reported from North American frogs.

Including the earlier reported forms, the North American frogs harbor the following nematode parasites:

<i>Rana catesbeiana</i>	<i>Rhabdias ranæ</i>
<i>Isociella quadrituberculata</i>	<i>Oswaldocruzia pipiens</i>
<i>Aplectana americana</i>	<i>Oswaldocruzia collaris</i>
<i>Falcustra catesbeianæ</i>	<i>Aplectana americana</i>
<i>Foleyella ranæ</i>	<i>Rana clamitans</i>
<i>Rana pipiens</i>	<i>Rhabdias bufonis</i> ?
<i>Isociella solitaria</i>	<i>Hyla carolinensis</i>
<i>Rhabdias ranæ</i>	<i>Cosmocercella haberi</i>
<i>Oswaldocruzia pipiens</i>	<i>Oswaldocruzia leidy</i>
<i>Oswaldocruzia subauricularis</i>	<i>Agamascaris enopla</i>
<i>Aplectana americana</i>	<i>Agamascaris odontoccephala</i>
<i>Aplectana longicaudata</i>	<i>Acris gryllus</i>
<i>Foleyella americana</i>	<i>Rhabdias ranæ</i> (larval forms)
<i>Pharyngodon batrachiensis</i>	"Frog"
(ex tadpole)	<i>Physcocephalus sexalatus</i>
<i>Rana palustris</i>	(larval forms)
<i>Rhabdias bufonis</i> ?	

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## EXPLANATION OF PLATE XVI

*Rhabdias ranae*

Scales on all figures represent 0.1 mm.

- Fig. 1.—Anterior end of female—lateral view.
- Fig. 2.—Anterior portion of male—lateral view.
- Fig. 3.—Head of female—terminal view.
- Fig. 4.—Tail of female—ventral view.
- Fig. 5.—Embryonated egg.
- Fig. 6.—Rhabditoid larva from intestine.
- Fig. 7.—Strongyloid larva from intestine.
- Fig. 8.—Ensheathed larva from coelom.
- Fig. 9.—Anterior end of larva after third ecdysis.
- Fig. 10.—Posterior end of larva after third ecdysis.



WALTON—SOME NEMATODES OF NORTH AMERICAN FROGS

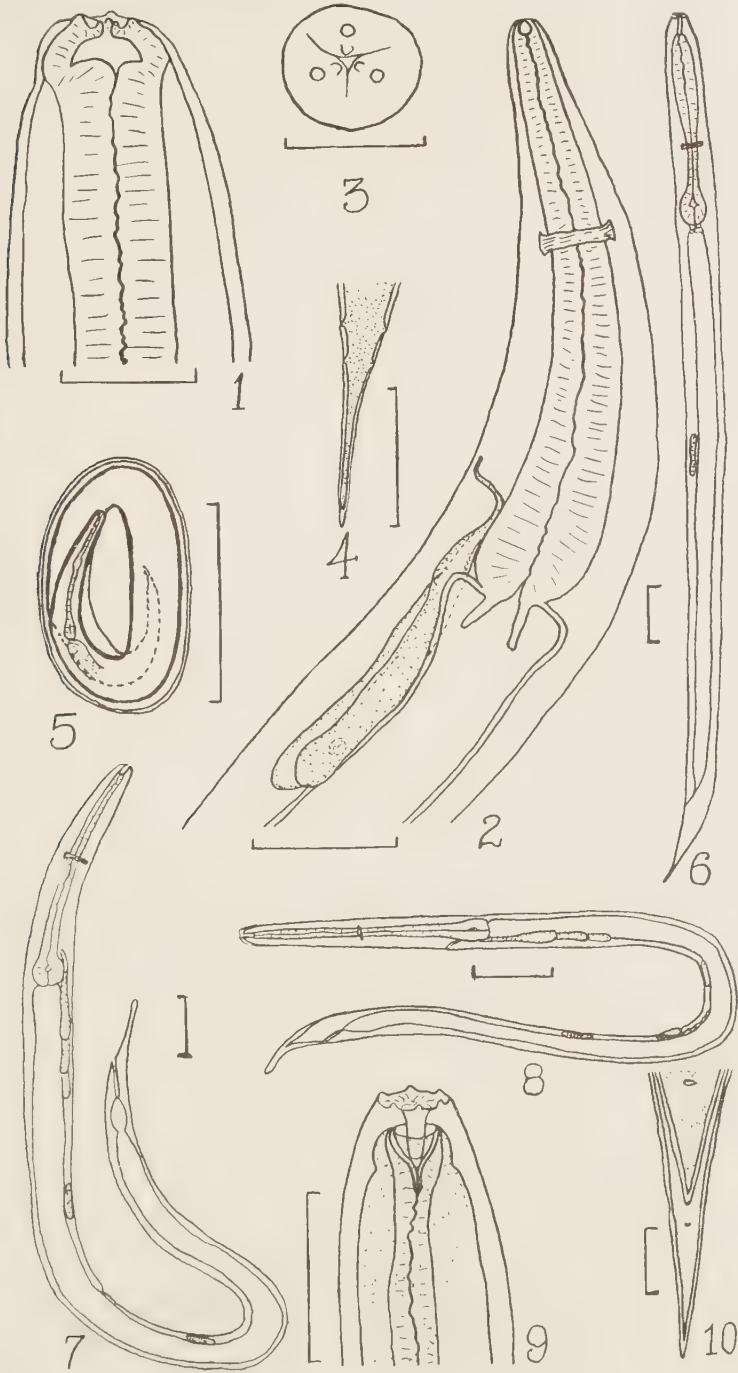


PLATE XVI

EXPLANATION OF PLATE XVII

Scales on all figures represent 0.2 mm.

Fig. 11.—*Oswaldocruzia pipiens*. Anterior end of female—ventral view

Fig. 12.—Tail of female—lateral view.

Fig. 13.—Tail of male—lateral view.

Fig. 14.—Tail of male—dorsal view.

Fig. 15.—Diagram comparing patterns of the dorsal rays of

a. *O. pipiens*

b. *O. auricularis*

c. *O. leidyi*

Fig. 16.—*Oswaldocruzia collaris*. Anterior end of female—lateral view.

Fig. 17.—Tail of female—lateral view.

Fig. 18.—Vulvar region—lateral view.



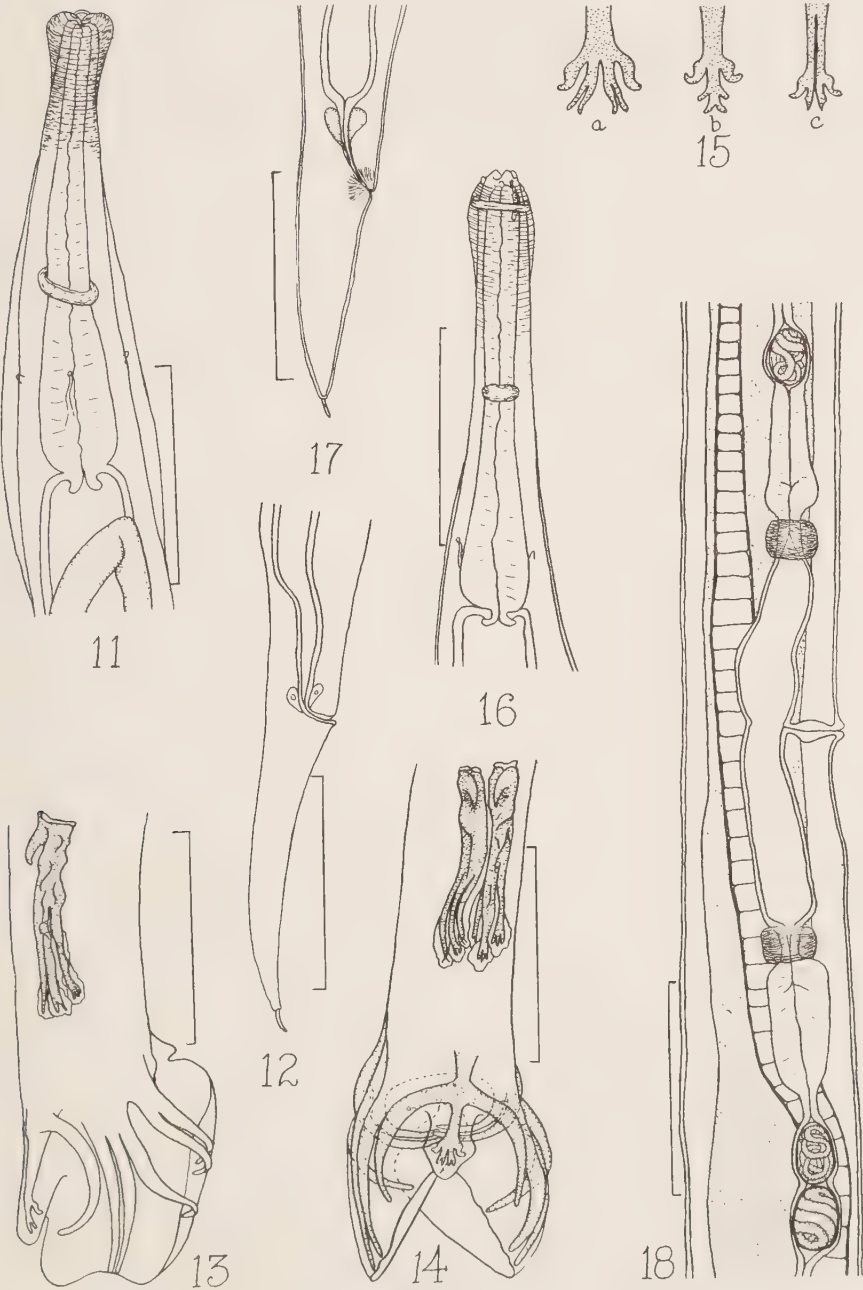


PLATE XVII

EXPLANATION OF PLATE XVIII

Scales on all figures represent 0.2 mm. except in figure 24 which represents 0.05 mm.

- Fig. 19.—*Oswaldocruzia subauricularis*. Anterior end of female—lateral view.
- Fig. 20.—Tail of female—lateral view.
- Fig. 21.—Vulvar region—lateral view.
- Fig. 22.—*Pharyngodon batrachiensis*. Anterior end of female—lateral view.
- Fig. 23.—Posterior end of female—lateral view.
- Fig. 24.—*Aplectana americana*. Head of female—dorsal view.
- Fig. 25.—Anterior end of male—lateral view.

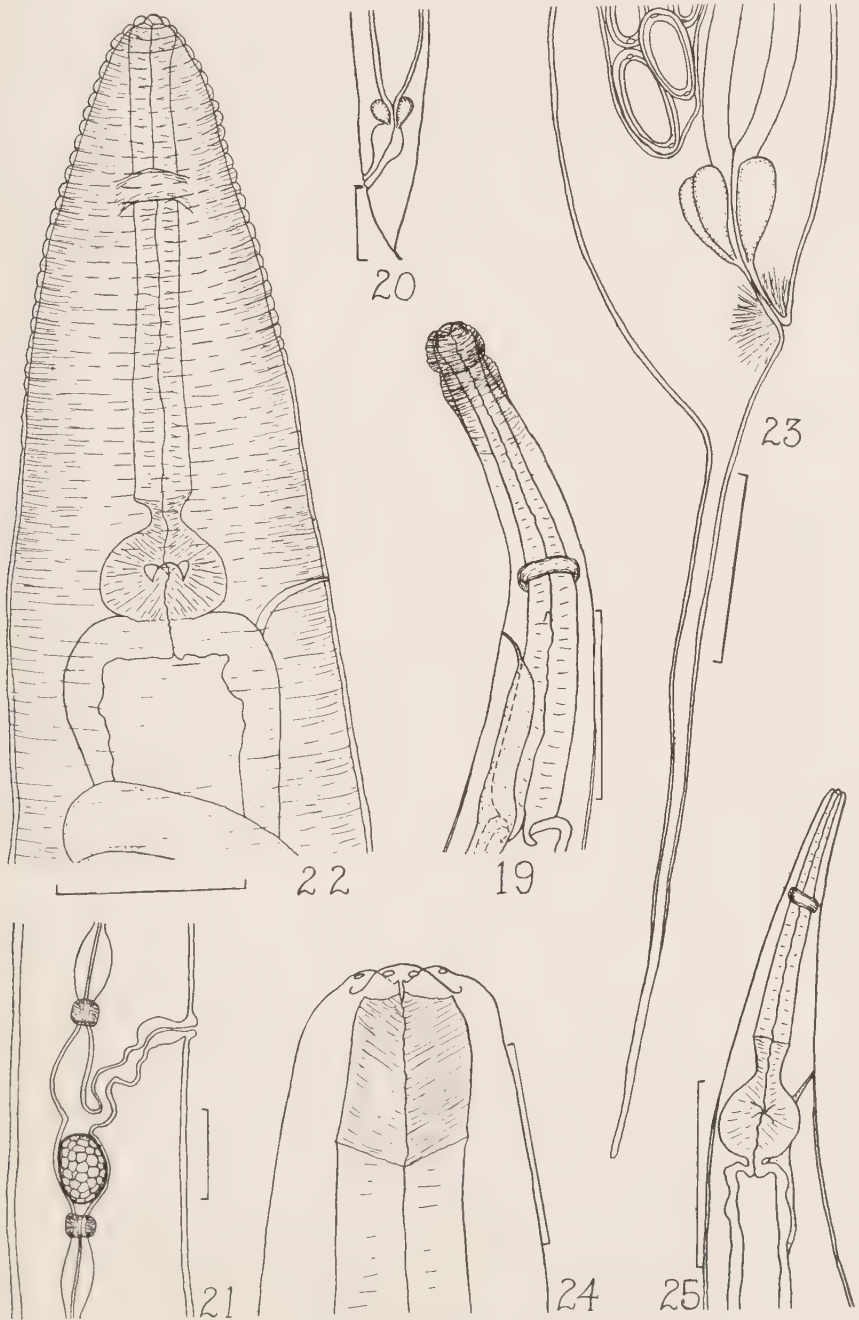


PLATE XVIII



EXPLANATION OF PLATE XIX

Scales on all figures represent 0.2 mm. except in figures 28 and 31 which represent 0.05 mm.

Fig. 26.—*Aplectana americana*. Tail of male—lateral view.

Fig. 27.—Tail of female—ventral view.

Fig. 28.—*Aplectana longicaudata*. Head of female—dorsal view.

Fig. 29.—Tail of male—lateral view.

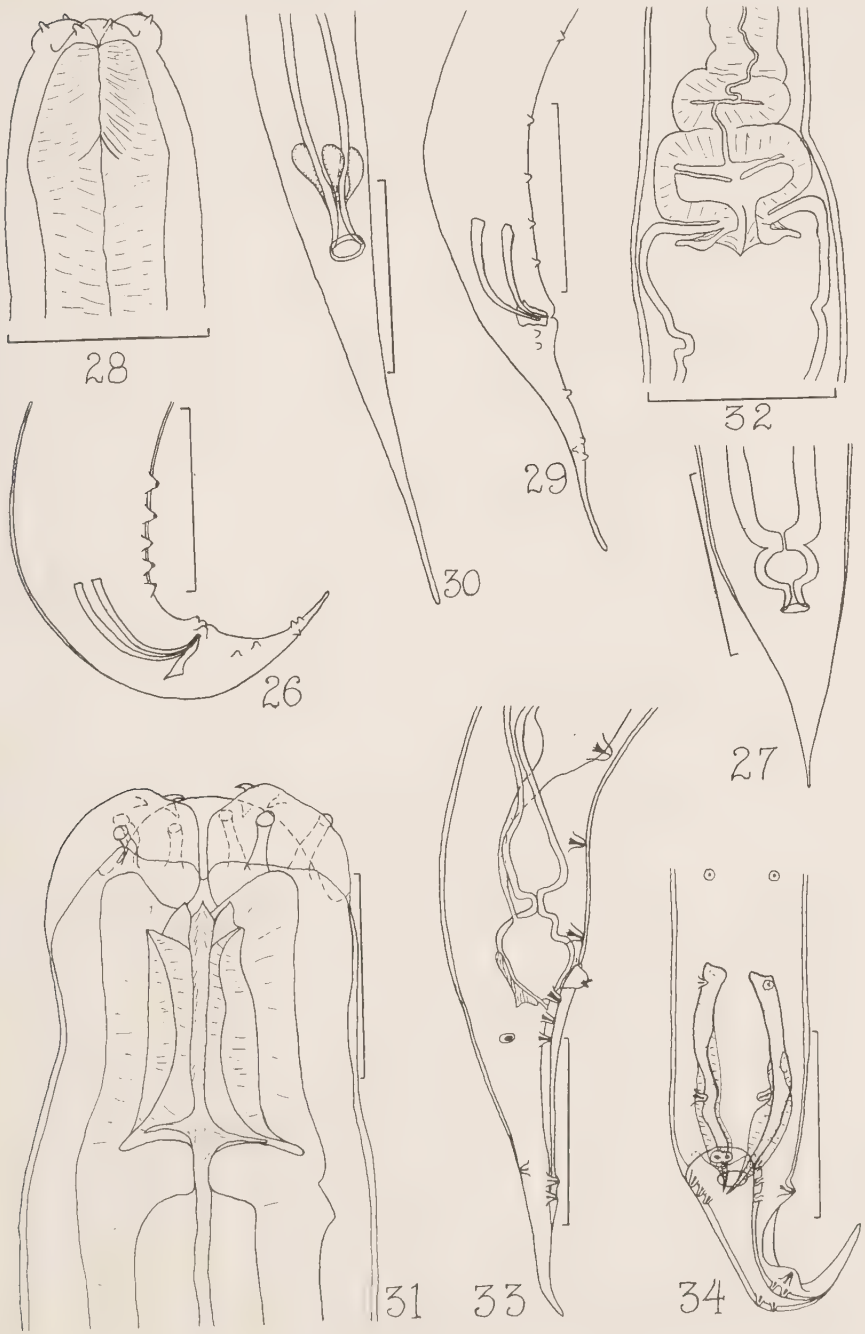
Fig. 30.—Tail of female—ventral view.

Fig. 31.—*Falcustra catesbeiana*. Head of male—ventral view.

Fig. 32.—Bulbar region of esophagus.

Fig. 33.—Tail of male—lateral view. Accessory piece shown, spicules omitted.

Fig. 34.—Tail of male—ventral view. Spicules shown, accessory piece omitted.



EXPLANATION OF PLATE XX

Scales on all figures represent 0.2 mm.

- Fig. 35.—*Falcaustra catesbiana*. Vulvar region—lateral view.  
Fig. 36.—Tail of female—lateral view.  
Fig. 37.—*Folecyella ranae*. Anterior end of female—ventral view.  
Fig. 38.—Head of female—ventral view.  
Fig. 39.—Head of female—terminal view. Same scale as in Fig. 38.  
Fig. 40.—Tail of male—ventral view.  
Fig. 41.—Tail of female—ventral view.  
Fig. 42.—*Folecyella americana*. Anterior end of female—ventral view.  
Fig. 43.—Tail of female—ventral view.



WALTON—SOME NEMATODES OF NORTH AMERICAN FROGS

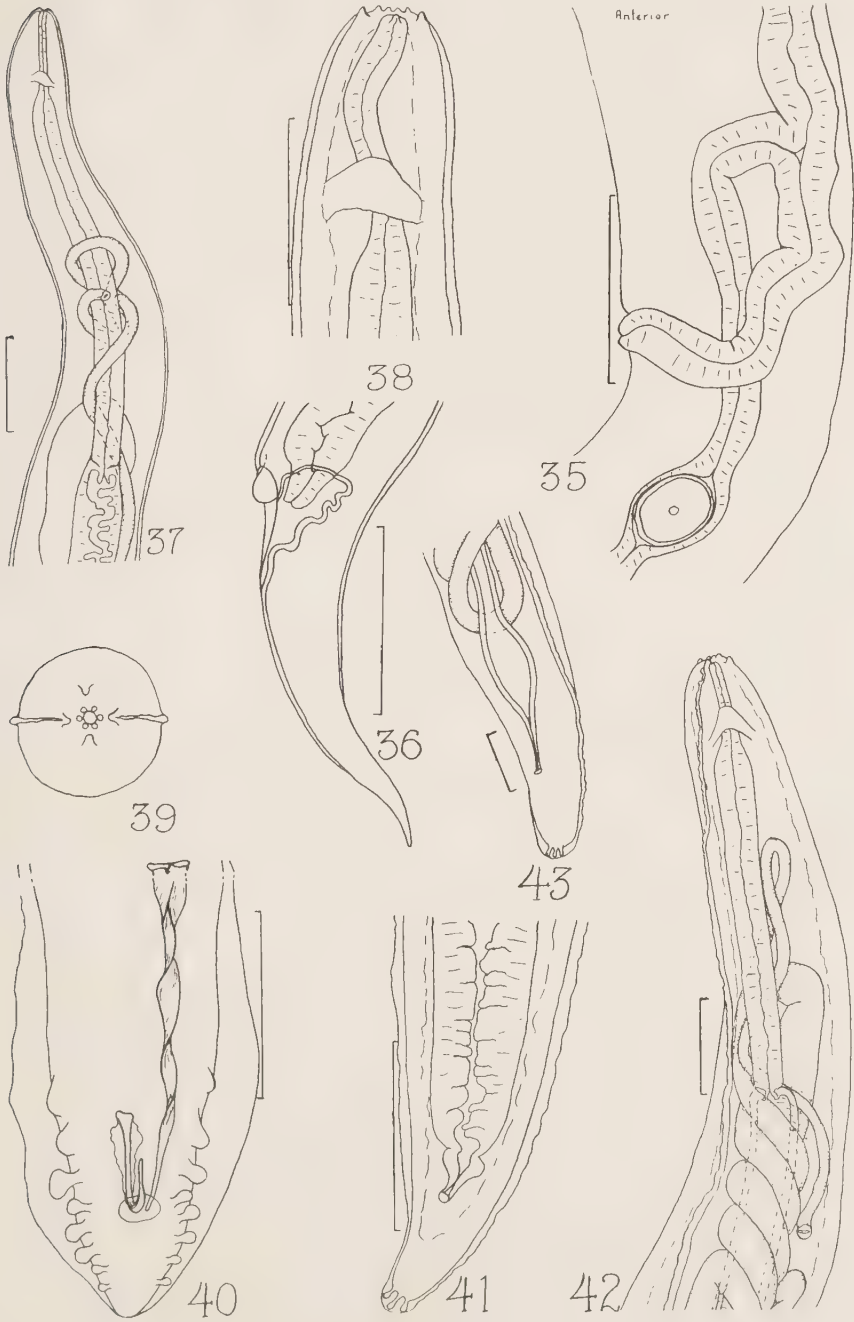


PLATE XX



# A QUANTITATIVE STUDY OF POULTRY COCCIDIOSIS

WITH DATA ON THE PREPATENT AND PATENT PERIODS IN THE  
LIFE CYCLE OF *Eimeria avium* \*

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Little was known of the life cycle of the fowl coccidium from the time Eimer in 1870 referred to the presence of this organism in the intestine of fowls until Fantham (1910) and Hadley (1911) gave general accounts of its life history and figures of various stages in the development of this parasite. Fantham gave some estimates as to the duration of the prepatent period of fowl coccidiosis, that is, the time from the entrance into the host until the appearance of the parasite in the feces, but his figures have been decreased by later investigators to such an extent that the methods employed in Fantham's work must be judged faulty. The discrepancies between Fantham's and the opinions of more recent workers in regard to the duration of the prepatent period of *Eimeria avium* led the writer to begin his investigations by checking up on this time interval. While working on the life cycle of the organism the question of whether unsegmented oocysts might not be capable of producing infections presented itself, and finally an attempt was made to study the course of infection caused by this coccidium by counting the number of oocysts shed daily during the patent period or during the time from the appearance until the disappearance of the parasite in the feces of its host.

As work progressed results were secured which seemed to support one of Johnson's (1927) statements that "the disease runs a limited course and most fowls completely expel the parasite in the feces" but observations warranted a further test of the hypothesis suggested in the same paper that experimental inoculations might be used to produce resistance or even immunity to the disease. The effect upon a single fowl of three consecutive inoculations at intervals of one month apart are shown in the curve accompanying this paper.

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\* The contents of this paper are the result of investigations carried on in the Department of Protozoology of the Johns Hopkins School of Hygiene and Public Health during a sabbatic leave from the Department of Zoology, Cornell University. The writer is indebted to the School of Hygiene and Public Health for the opportunity of carrying on this work in its well equipped laboratory, and wishes to express his gratitude to Dr. Robert Hegner and his colleagues for their many courtesies and helpful suggestions.



## MATERIALS AND METHODS

Only incubator chicks were used as experimental animals. These were received before the first feeding and placed in sterilized cages in which the necessary heat supply was through electric light bulbs. As safeguards against insects as possible vectors of oocysts, cages were covered with two layers of cheese cloth and a number were not only covered but suspended from a wire stretched across the room, thus elevating the cage from the floor or tables. Food, furnished largely by the Purina Mills, was sterilized by heat before using. In each case the experimental chick was taken from the common pen and observed in individual cages, the bottoms of which were of one-half inch wire mesh. By this means re-infection was prevented as droppings would pass through this mesh and could be collected on paper toweling provided below.

Instead of using the smear method of detecting oocysts in the feces, a suitable modification of the direct centrifugal flotation method used by Lane (1922) for the mass diagnosis of hookworm infestation was the one employed. This method (termed D. C. F.) was quite similar to the one used by Andrews (1926) in his work on cats. The following is the modification of the direct centrifugal flotation method used: Droppings to be examined were placed in strong 100 cc. Erlenmeyer flasks with enough distilled water to make a good suspension medium and a small number of #4 shot were added. Flasks were then closed with a rubber cork and shaken until the contents were uniformly mixed and all solid particles finely comminuted. In case the presence or absence of oocysts was the only information desired, the emulsion was strained through a couple of layers of cheesecloth in order to free the suspension of shot and other large particles. The filtrate was then poured into round-bottomed 15 cc. centrifuge tubes of resistant glass. The lower speeds of an electric centrifuge (1300 to 1850 rpm or thereabouts) was found sufficient to throw down the oocysts to the bottom in such a compact mass that the supernatant fluid could be poured off. To this mass of oocysts and debris remaining in the tube was added a salt solution (18.5% up to saturated) and the mixture stirred with a glass rod until the suspension could be poured into a flat-bottomed centrifuge tube. This tube was then balanced in a hand centrifuge with another tube filled with water and just enough more of the salt solution added to the suspension-containing tube to permit a cover slip to be placed over the opening in such a way that either a very small one or no air bubble appeared below the cover slip. (An 18 mm. square, #3 cover slip was found suitable for this purpose). A centrifuge speed of about 1100 rpm continued for a little more than a minute was found sufficient to force the oocysts to the top of the tube where they will collect on the

cover slip and may be removed with it as it is lifted (rather quickly) from the tube and placed on a slide for examination. Oocysts may be detected by this means when they are present in such small numbers as to be overlooked in the ordinary smear method of examination.

In the quantitative studies of the number of oocysts liberated daily by an infected chick the above method was used with the following additions or modifications: All the fecal droppings of the chick under observation were collected each day, mixed thoroughly, and a sample of two grams (out of an average 20 grams total) placed in a strong 100 cc. Erlenmeyer flask in which the bottom had been arched inwards, by means of heat, to such an extent that a 90 cc. mark might be etched about the neck of the flask. This made possible a more accurate measurement of the standard volume of 90 cc., which was decided upon for use in the quantitative work, on account of the small diameter of the neck as compared with the body of the flask. To the two grams of droppings in the flask enough distilled water was then added to bring the level of the suspension up to the 90 cc. mark on the neck. By adding #4 shot the mixture could be agitated thoroughly, and a satisfactory amount, such as 15 cc. commonly used, might be poured out in a round-bottomed 15 cc. centrifuge tube. The method of floating up the oocysts contained in this amount of suspension and collecting the same on an 18 mm. square cover slip has been mentioned above. After having removed the first cover slip from the top of the centrifuge tube to a slide and counted the oocysts adhering to same, a few drops of salt solution was added to the contents of the centrifuge tube and a second cover slip dropped upon it, more oocysts floated up by repeating the process of centrifuging and these counted. The same procedure was repeated with additional cover slips until practically all the oocysts had been floated up from the 15 cc. of suspension. The total of the counts secured from individual cover slips gave the number of oocysts appearing in  $\frac{1}{3}$  gram of droppings voided during any day. (2 grams of fecal material was used each day in distilled water sufficient to make 90 cc. of suspension, but only 15 cc. of this suspension was taken for use in making oocyst counts.) At times during the quantitative studies 15 cc. of suspension was found to be too much on account of the difficulty of counting too large a number of oocysts on a cover slip. At such times a smaller quantity, such as 5 cc. of the suspension, was used, but in all cases the figures appearing on the accompanying curve represent the number of oocysts reduced to the standard of  $\frac{1}{3}$  gram of fecal material. The number of oocysts shed during any one day can be computed roughly by multiplying the figure on the curve by sixty.

All inoculations were by means of a rubber-tipped syringe, directly into the crop of the chick. The commonest method used in preparing the

inocula was as follows: Droppings collected from chicks at the height of their infection were usually used in preparing inocula. These droppings, containing unsegmented oocysts, were comminuted in a 2.5 per cent solution of potassium bichromate in water and spread out in petri dishes to allow the oocysts to sporulate. Only sufficient potassium bichromate solution to keep the mixture moist is necessary to keep down bacterial growth and insure the sporulation of the oocysts. This process is accelerated by supporting the cover of the petri dish on a couple of wooden strips laid across the top of the portion containing the feces, thus allowing a free circulation of air over the material. Oocysts were concentrated by using the D. C. F. method already discussed, but instead of placing a cover slip on top of the flat-bottomed centrifuge tube on which to collect the oocysts, the tube was left open and the oocysts were allowed to collect at the top. These were then lifted from the centrifuge tube to a round-bottomed centrifuge-tube by means of a piece of hollow glass tubing, washed with water, and the number of oocysts determined by means of a Levy Counting Chamber. The average of two counts was accepted for most of the suspensions used in inoculations.

#### THE PREPATENT PERIOD USING SEGMENTED OOCYSTS

In Table #1 are listed enough cases of experimentally inoculated chicks, together with the time elapsing from inoculation until the oocysts appeared in the feces, to establish a fairly accurate prepatent period for *Eimeria avium*. In all cases with the exception of #43, which was a white leghorn, the chicks were of the barred rock breed. Judging from the single white leghorn cited above the prepatent period is a few hours less in this breed of chick than in barred rocks.

From the foregoing data it can be seen that the prepatent period, reckoned by Fantham (1910) as 8 to 10 days and by Johnson (1923, 1927) as 6 days, is in reality a much shorter time, at least four to five hours less than 4 days in the case of barred rock chicks and probably a slightly shorter period in the case of white leghorns.

#### ARE UNSEGMENTED OOCYSTS DANGEROUS?

In the more recent literature on coccidiosis of chickens the statement is often seen that unsegmented or unsporulated oocysts are not dangerous. To become dangerous they must become segmented, and this requires a period of two or three days after the oocysts were voided in droppings (Beach and Davis, 1925). Having apparently produced the disease by inoculating with unsegmented oocysts the writer decided to check his results with a number of experiments, the object of which was to determine the shortest period of time required for unsegmented oocysts to become infective after these were voided from their host.



Table 2 lists the results of these experiments in which unsegmented oocysts were administered.

A glance at Table 2 shows that in eight chicks (Nos. 50, 51, 52, 54, 55, 56, 62, and 65) inoculated with unsegmented oocysts which had been out of the bodies of the hosts, from which these were secured, periods ranging from 1 hr., 15 min. up to 6 hrs., 25 min., not a single infection occurred, but in chicks No. 14, 5, 57 and 66 infections did occur after inoculations with unsegmented oocysts after periods of from 1 hr., 45 min. up to 6 hrs., 30 min. after hosts had voided the fecal material containing the oocysts used in inoculating. Nos. 63 and 64 have been

TABLE 1.—*Prepatent Period in Eimeria avium Infections*

No.	Hatched	Time of Inoculation	Number of Oocysts Administered	Negative Fecal Examinations	Appearance of Oocysts	Prepatent Period
29	9/26/27	10/ 5/27, 2:00 p.m.	900 O.	10/7 and 8	10/9, 9:00 a.m. (17 on cover)	Not over 3 days, 19 hours
15	9/26/27	10/13/27, 11:30 a.m.	25,000 O.	10/11	10/17, 10:15 a.m. (305 on cover)	Not over 3 days, 22¾ hours
43	11/30/27	12/29/27, 4:10 p.m.	53,000 S. O. 97,166 U. O.	1/1 (11:30- 4:30)	1/1, 4:30 p.m.; 1/2, 9 to 10 a.m. (88 on cover)	Not over 3 days, 17 hours
63	12/ 1/27	12/31/27, 10:35 a.m.	153,333 S. O. 524,444 U. O.	.....	1/3, 4 p.m. to 1/4, 8:45 a.m. (7 on cover); dropping voided at 10:25 a.m. gave plenty of oocysts	Not over 3 days, 22 hours, 10 min- utes
64	12/ 1/27	12/31/27, 10:40 a.m.	160,666 S. O. 576,999 U. O.	1/3	1/3, 4 p.m. to 1/4, 8:45 a.m. (7 on cover)	Not over 3 days, 22 hours, 5 min- utes
69	12/ 1/27	1/ 9/28, 3:55 p.m.	960,000 S. O. 760,000 U. O.	1/11	1/13, 11:45 a.m. (1 on cover) 1/13, 11:55 a.m. (plenty on cover)	Not over 3 days, 19 hours, 50 min- utes
70	12/ 1/27	1/11/28, 12:05 p.m.	740,000 S. O.  780,000 U. O.	1/13	1/14, 4 p.m. until 1/15, 9 a.m. (5 on cover) 1/15, 9:10 a.m. (plenty on cover)	Not over 3 days, 20 hours, 55 min- utes
21	3rd inoc- ulation 9/26/27	1/11/28, 11:30 a.m.	403,333 S. O.  572,222 U. O.	1/13 and 14	1/14, 8:30 a.m. until 1/15, 9 a.m. (1 on cover) 1/15, 9:00 a.m. until 1/16, 8:30 a.m. (thousands)	Not over 3 days, 21 hours, 30 min- utes

\* When no consideration was given to the condition of the oocysts used in inoculating, the letter O appears after the number. If the number of segmented oocysts as compared with the number of unsegmented ones was determined the number of the former has the two letters S. and O. after it while the number of the latter has the letters U. and O. following it.

included to show that less than twenty-four hours is necessary to insure segmentation of some oocysts and therefore infection occurs in the usual prepatent period of sporulated oocysts, namely, a few hours less than four days. Observations on chicks Nos. 71 and 72 do not appear in table 2 as infection broke out in the control pen at this time. However, both of these chicks showed oocysts in their droppings within the expected time after having been inoculated with 1,905,000 and 1,270,000 unsegmented oocysts, respectively, after these had been shed for 15 hours.

## COURSE OF DISEASE AS INDICATED BY NUMBER OF OOCYSTS VOIDED DAILY

The curve included in this paper represents a quantitative study of coccidiosis as indicated by the number of oocysts discharged daily during each of three consecutive infections. These infections were the

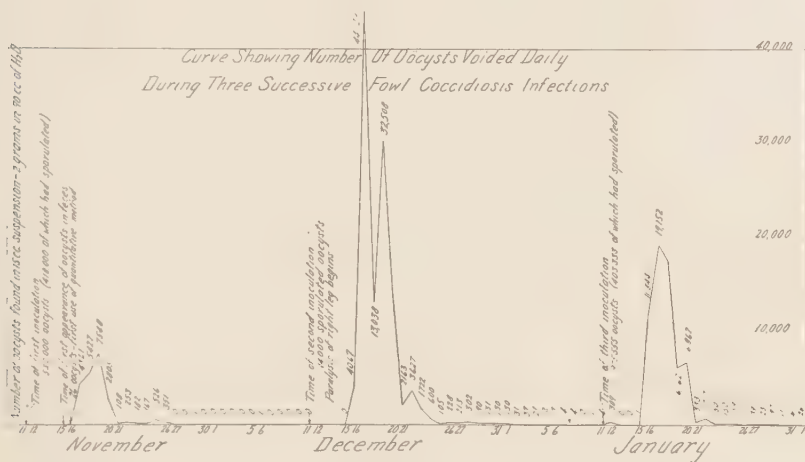
TABLE 2.—*Results of Administering Unsegmented Oocysts to Chicks*

No.	Hatched	Time from Voiding Until Inoculation	Time of Inoculation	Amount	Nega- tives	Appearance of Oocysts	Prepatent Period
14	9/26/27	1 hour 45 min.	10/12/27, 10:30 a.m.	5,000	10/14, 15 and until 10/16, 2:45 p.m.	10/17, 2:30 until 3:45 (365 oocysts on cover)	Not over 5 days, 5½ hours
5	9/26/27	3 hours 50 min.	10/24/27, 1:20 p.m.	60,000	10/26, 27, 28 up to 10/29 8 a.m.	10/29, 8:00 a.m. until 5:00 p.m. (large number of oocysts on cover)	Not over 5 days, 3 hours, 40 min- utes
57	12/ 1/27	5 hours 45 min.	12/28/27, 2:45 p.m.	323,000	None	1/1, 9:30 a.m. until 1/2, 9:30 a.m. (60 oocysts on cover); 1/2, 9:30 a.m. until 1/2, 12:30 p.m. (thousands on cover)	Not over 4 days, 18 hours, 45 min- utes
63	12/ 1/27	24 hours 20 min.	12/31/27, 10:35 a.m.	153,333 S. O. 524,444 U. O.	None	1/3, 4:00 p.m. until 1/4, 8:45 a.m. (7 oocysts on cover); 1/4, 10:25 a.m. (plenty in single dropping)	Not over 3 days, 22 hours, 10 min- utes
64	12/ 1/27	24 hours 25 min.	12/31/27, 10:40 a.m.	160,666 S. O. 576,999 U. O.	1/3	1/3, 4:00 p.m. until 1/4, 8:45 a.m. (7 oocysts on cover)	Not over 3 days, 22 hours, 5 min- utes
66	12/ 1/27	6 hours 30 min.	1/1/28, 4:05 p.m.	1,117,777	1/5, 8:30 a.m. until 1/6, 8:45 a.m.	1/6, 8:45 a.m. until 10:45 a.m. (11 oocysts on cover)	Not over 4 days, 18 hours, 40 min- utes
50	12/ 1/27	2 hours 5 min.	12/ 9/27, 10:45 a.m.	6,666			
51	12/ 1/27	1 hour 15 min.	12/ 9/27, 11:55 a.m.	12,832			
52	12/ 1/27	3 hours 50 min.	12/15/27, 1:05 p.m.	1,200			
54	12/ 1/27	3 hours 57 min.	12/20/27, 1:12 p.m.	5,000			
55	12/ 1/27	4 hours	12/22/27, 1:45 p.m.	70,000			
56	12/ 1/27	3 hours 45 min.	12/24/27, 12:55 p.m.	26,000			
62	12/ 1/27	6 hours 10 min.	12/29/27, 3:25 p.m.	1,483,333			
65	12/ 1/27	6 hours 25 min.	1/1/28, 4:00 p.m.	2,794,444			

result of feeding oocysts to a chick on three separate occasions just one month apart, the first inoculation being on November 11, 1927, when the chick was forty-five days old. The number of oocysts injected into the crop of this chicken and the method employed in estimating the number of oocysts voided, in a chosen quantity of feces, daily, are explained under the section on Methods above.

Attention is called to the fact that the experimental chicken developed a bad case of leg paralysis which was noticed first during the prepatent period of the second infection. Paralysis continued until the chicken was killed on February 2, 1928, the case growing worse with age. Neither the paralysis nor the coccidiosis infections seemed to materially affect the appetite of the animal.

Pappenheimer, Dunn and Cone (1926) in their study of fowl paralysis came to the conclusion that, "No relation has been found between paralysis and infestation with coccidia or intestinal worms." Beach and Davis (1925) assume fowl paralysis to be the result of a chronic type of coccidiosis. Certainly all other infective organisms were carefully guarded against in the rearing of this chicken and yet paralysis



appeared at a time coinciding with the prepatent period of the second infection.

An examination of this curve will show a number of important facts:

1. Experimental inoculation of this cage-reared fowl did not develop immunity nor even a high degree of resistance. (As this paper was being prepared for publication, a paper by Johnson, 1927a, appeared in which he summarized the following as one of his conclusions: "A high degree of resistance, if not immunity, may be regularly developed by experimental inoculation.")

2. After each inoculation oocysts began to appear in the feces in a little less than four days and most had been shed by the tenth day after inoculation. Large numbers of oocysts were shed from the fifth to the tenth day after inoculation, indicating that the acute stage of the disease is slightly in advance of this period.

3. From the tenth day on, the number of oocysts shed gradually decreases at a rate corresponding somewhat with the severity of infection until indications of the disease (oocysts in feces) were lost altogether.

4. No correlation was shown between the number of oocysts given and the severity of the resulting infection as gauged by the number of oocysts shed daily.

5. At the height of one of the infections, approximately 2,648,340 oocysts were voided in one day.

6. The curve indicates that a great many merozoites re-enter the tissue cells as trophozoites instead of forming gametocytes but the number of merozoites re-entering two or more times is relatively few.

TABLE 3.—*Eimeria avium* Oocyst Measurements

Length Microns	Breadth—Microns																Total
	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
10	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	
11	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	
12	4	4	5	..	..	..	..	..	..	..	..	..	..	..	..	13	
13	1	1	7	5	..	..	..	..	..	..	..	..	..	..	..	14	
14	..	..	25	24	8	..	..	..	..	..	..	..	..	..	..	52	
15	..	1	6	6	5	..	..	..	..	..	..	..	..	..	..	18	
16	..	..	13	26	17	..	..	..	..	..	..	..	..	..	..	56	
17	..	..	1	4	8	1	1	..	..	..	..	..	..	..	..	15	
18	..	..	9	5	15	1	..	..	..	..	..	..	..	..	..	30	
19	..	..	..	1	6	1	1	..	..	..	..	..	..	..	..	9	
20	..	..	1	..	10	..	2	..	..	..	..	..	..	..	..	13	
21	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
22	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	1	
23	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
24	..	..	..	..	..	..	..	1	..	..	..	1	..	..	..	2	
25	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
26	..	..	..	..	..	..	..	..	..	1	..	1	..	..	..	2	
27	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1	
28	..	..	..	..	..	..	..	..	1	1	7	1	..	..	..	10	
29	..	..	..	..	..	..	..	..	1	1	1	..	..	..	..	3	
30	..	..	..	..	..	..	..	..	..	1	2	2	..	..	1	6	
31	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1	
32	..	..	..	..	..	..	..	..	..	1	1	1	..	..	1	4	
Total	7	6	68	71	64	3	4	1	2	4	13	5	2	..	2	252	

7. Some indication of the number of oocysts which might pass through the intestine of a host without excysting is given on the curve during the third prepatent period in which 309 oocysts were recovered during the first day after inoculation. This would indicate a total of about 18,540 oocysts shed during the day.

8. This case lends support to the assumption by Beach and Davis that fowl paralysis is the result of a chronic type of, or at least a severe case of, coccidiosis rather than to Pappenheimer, Dunn and Cone's view that there is no relation between paralysis and infestation with coccidia.

#### EVIDENCE OF MORE THAN ONE ORGANISM PRESENT DURING COCCIDIOSIS INFECTIONS

Table 3 shows the distribution of 252 measured oocysts. Two distinct sizes are strikingly brought out by plotting these according to



their lengths and breadths. The smaller oocysts average from 12 to 14 $\mu$  in width and from 14 to 16 $\mu$  in length, while the larger ones average 19 to 21 $\mu$  in width and from 28 to 30 $\mu$  in length. Coupled with the fact that the space within the cyst walls of the larger oocysts appears pinkish in contrast with the transparent condition of the smaller oocysts, one cannot avoid the conclusion that one is dealing with two distinct organisms. Perhaps Tyzzer (1927) is right in contending that one of these is more pathogenic than the other, and should be known as *Eimeria tenella*.

#### CONCLUSIONS

1. The prepatent period of avian coccidiosis, using barred rock chicks and segmented oocysts is from four to five hours less than four days.

2. Unsegmented oocysts ingested a few hours after being voided by the host may produce coccidiosis while unsegmented oocysts ingested from 12 to 18 hours after being shed are quite likely to produce the disease. The length of time a chick will retain oocysts within its intestine is a factor in infections.

3. Oocysts apparently do not begin to segment until after exposure to the air. No sign of segmentation could be seen in oocysts pent up in the rectum and cloaca of a chick for two and three days, respectively. Degeneration through the attack of bacteria was noted in the enclosed cytoplasm of many of these.

4. If the chick is kept from reinfection the disease will run a rather limited course, but immunity to later infections does not seem to be developed by experimental inoculation.

5. Measurements and color of oocysts seem to indicate the presence of two different organisms in some coccidiosis infections. These may represent two different species, *Eimeria avium* (Rivolta and Silvestrini) and *Eimeria tenella* (Railliet and Lucet).

6. The appearance of fowl paralysis in a chicken which had been inoculated with oocysts a second time and had lived its entire life under two layers of cheese cloth supports the assumption that fowl paralysis is one of the symptoms of chronic coccidiosis rather than in no way connected with infestation with coccidia.

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## THE GENUS DIORCHIS

WITH DESCRIPTION OF FOUR NEW SPECIES FROM NORTH AMERICA

ROY L. MAYHEW

The genus *Diorchis* was established by Clerc in 1903 who defined it in the following manner (p. 288): "Cestodes d'oiseaux à proglottis très nombreux et courts. Crochets du rostellum en petit nombre et en couronne simple. Pores génitaux unilatéraux. Deux testicules par proglottis. Muscles longitudinaux divisés en 2 couches, dont, l'interne ne comprend que 8 faisceaux. L'utérus sacciforme remplit tout le proglottis mûr." Subsequent studies have revealed the value of these characters as diagnostic of the genus, the most easily determined and important of which being the number of testes. The type of the genus has been designated as *D. acuminata* (Clerc) 1902.

The following species besides the type have been assigned to the genus: *Diorchis americana* Ransom 1909, *D. flavescens* (Kreff) 1871, *D. inflata* (Rudolphi) 1809, *D. parviceps* (von Linstow) 1872, and *D. excentrica* Mayhew 1925. Below are presented the descriptions of four species which are believed to be new,

### *Diorchis spinata* n. sp.

The specimens upon which the following description is based were obtained from two godwall or gray ducks, *Chaulelasmus streperus*, which were shot in the Louisiana marshes in Cameron Parish, 18 miles west of Lake Arthur, Louisiana on November 24, 1927. The material is in the author's collection under the host numbers of 737 and 738.

The length of mature or nearly mature specimens varied from 80 to 122 mm., while the maximum width is about 1.3 mm. The scolex is somewhat wider than the neck region measuring about 0.25 mm. in width. It also measures about the same distance from the terminal portion to the base of the suckers. The rostellum was retracted in all the specimens obtained, and is not an introvert as is indicated by text figure *a*. It carries a single crown of ten hooks, which are 46 to 48 $\mu$  in length, and have the shape indicated in figure 5.

The two testes are centrally located in the proglottid, and when fully developed extend the full length of the proglottid (Fig. 6). Until they begin to degenerate they take stains well and are conspicuous, but after the female reproductive organs begins to mature they rapidly disappear. The cirrus sac is a prominent structure, and reaches  $\frac{1}{2}$  to  $\frac{3}{4}$  the width of the proglottid, often to the antiporal excretory vessel. This variation in relative length is apparently due to differences in the contraction of

the muscles of the proglottid. The sac is of nearly uniform diameter throughout, only decreasing slightly from the region of the poral excretory vessel toward the margin of the proglottid. It is often bent apparently because of pressure from other organs in the proglottid. There is both an internal and an external seminal vesicle, the external being large and conspicuous when distended by the spermatozoa in the older proglottids (Fig. 1). The internal seminal vesicle occupies about the inner three fourths of the cirrus sac. The cirrus is conspicuous when protruded (Fig. 4). It measures about 0.15 mm. in length, and about 0.02 mm. in diameter at the base. The proximal half in some proglottids is of nearly equal diameter throughout, the terminal half tapering gradually to a small diameter at the tip. In other proglottids the entire organ tapers gradually from base to tip. The basal half of the cirrus is rather sparsely set with large conspicuous spines, most of which have their points directed toward the base of the organ.

The ovary is centrally placed, and reaches the excretory vessels on either side when fully developed. It is slightly lobed, and somewhat irregular in its shape (Fig. 3). The inner portion of the vagina is expanded to form a large seminal receptacle (Fig. 1). The mature eggs are cylindrical in shape, and have rounded ends (Fig. 2). The outer shell measures  $69$  to  $94\mu$  long and  $12$  to  $16\mu$  wide, and the inner  $40$  to  $53\mu$  long by  $8\mu$  wide. The embryo measures  $22$  to  $29\mu$  long, and is but little narrower than the width of the inner shell.

The outer muscles are arranged in a layer in the outer portion of the parenchyma, and the inner in four bundles of fibers on each side of the proglottid in the manner characteristic of the genus (Fig. 1). The ventral excretory vessel is several times the size of the dorsal, and those on the poral side are found ventral to the genital ducts. No transverse vessels were observed.

The above described species is much like *Diorchis flavescens*. There are some differences, however, which may be noted. The hooks of *D. flavescens* are  $68\mu$  long while in the above species they are  $45\mu$  although the shape is similar. The cirrus of *D. spinata* is shorter, 0.16 mm. as compared with 0.5 in *D. flavescens*, and much larger at the base, 0.02 mm. as compared with 0.0054 mm. The cirrus of *D. flavescens* has a minute armature, while *D. spinata* has very strongly constructed spines on the basal half of the organ. The cirrus is very much different from any of the described species.

*Diorchis bulbodes* n. sp.

The host from which the worms described below were taken was a mallard duck, *Anas platyrhynchos*, killed near Baton Rouge, La., December 20, 1926. They were found in the region of the intestine into which the ceca open, and since it is unusual to find cestodes of this



size in this position, it is possible that they reached this place after the death of the host. The fact that one specimen of an unidentified species was found among them of which a number were found in the small intestine also indicates this. Thirteen specimens were obtained with scoleces besides a number of pieces. They are catalogued in the author's collection under the host number 671c.

The most nearly mature specimens vary in length from 60 to 70 mm., while the immature measure about 40 mm. The width in the region where the testes are well developed is about 0.4 mm., while in proglottids with well developed uteri the width is 0.7 to 0.8 mm. A distinct neck region is present, and the scolex proper is but little wider than the neck although the suckers project considerably beyond the margins of the scolex (Fig. 9). The width of the scolex when well extended is about 0.2 mm. The rostellum is about 0.2 mm. long when well extended, and is but slightly enlarged at the tip. There is a single row of 10 hooks, which have the shape indicated in figure 13, and vary in length from 65 to 70 $\mu$ .

The two testes are near each other and are centrally placed (Fig. 7). They are often not of equal size. In some proglottids it is the right while in others it is the left that is the larger. The cirrus sac reaches to the center of the proglottid, and is at first difficult to find, but as the female organs begin to develop it becomes a conspicuous structure. When extruded the cirrus has a very characteristic shape as indicated by figure 12. It may be either slightly pear-shaped or broadly oval in outline. The surface is set with short thick spines, which have an irregular distribution. A spherical seminal vesicle is located at the inner end of the cirrus sac (Fig. 11).

The ovary extends to the lateral excretory vessels on either side when fully developed. It is irregularly lobed, and has a deep depression on the posterior margin within which is found the usually irregularly shaped vitelline gland (Fig. 11). The uterus varies in its extent but in most proglottids reaches well beyond the lateral excretory vessels (Fig. 10). Its outline is irregular, and in most of the specimens contained immature eggs. One specimen, however, possesses eggs which seem nearly mature. They are thin shelled, and usually so distorted that they could not be measured. Those which could be measured have outer membranes 58 to 64 $\mu$  long and 23 $\mu$  wide, and inner membranes 50 $\mu$  long and 15 to 19 $\mu$  wide. The embryos measure 30 to 40 $\mu$  long by 9 to 14 $\mu$  wide.

The muscles are arranged in the manner characteristic of the genus. The eight bundles of the inner layer are unusually large and composed of rather large fibers. The arrangement of the muscles in cross section is represented in figure 8.

When compared with other species it is found to structurally resemble *Diorchis flavescens* in many respects, but the cirrus is very different. The cirrus of *D. flavescens* is long and slender while in the above species it is short and thick.

*Diorchis kodonodes* n. sp.

The following description is based upon the study of one specimen of a tapeworm which was found on the outside of the intestines of two blue-wing teal, *Querquedula discors*, which had been placed together on a piece of paper after removal from the bodies of the birds to await examination. The intestines were badly torn by shot, and it would have been possible for it to have been drawn through the openings as they were removed. While it is not impossible for it to have come from some other species of duck, yet it seems very improbable, and since it represents a distinct species, it seems advisable to describe it at this time. The birds were shot in Cameron Parish, 18 miles west of Lake Arthur, La., on November 24, 1927. The specimen is preserved in the author's collection under the host number 768-9.

The length of the specimen is approximately 156 mm., and the maximum width 1.5 mm. In the region where the male reproductive organs are well developed the proglottids are approximately 0.7 mm. wide and about 0.1 mm. long. Those proglottids which have the female organs well developed are about 1.1 mm. wide while those with well developed uteri are about 1.5 mm. in width. The scolex could not be carefully studied because it became distorted in the process of fixation. The rostellum is retracted with the blades of the hooks toward the base of the scolex, and is, therefore, not an introvert. The hooks are approximately  $17\mu$  long, and have the shape indicated in figure 20.

The two testes are centrally placed in the proglottids. They are separated from each other a little, and the early stages of the ovary and vitelline gland begin their development in this intervening area (Fig. 15). The cirrus sac reaches about three fourths of the width of the proglottid in the earlier stages of development, but in the later rarely beyond the excretory vessels on the poral side. The cirrus is unusual in its structure when protruded (Fig. 18a). It consists of two portions, a basal enlarged part, which tapers distally, and a terminal part which is narrow at its point of attachment and somewhat bell-shaped at the free end. Some have been observed to have a few small spines on the basal portion. Figure 18b shows the partially extruded cirrus. A conspicuous external seminal vesicle is present near the end of the cirrus sac (Fig. 15) which, in the earlier proglottids, is rounded when viewed from the dorsal or ventral side of the proglottid, but in sections is found to be flattened dorsoventrally.

The ovary is centrally placed in the proglottid, its earlier stages developing directly between the testes (Fig. 15), but as development proceeds it grows laterally beneath them. Its shape varies considerably, but usually it is transversely elongated with one to three anterior lobes of varying sizes (Fig. 16). The vitelline gland is placed directly behind the ovary, and is usually rounded or oval in outline, but sometimes slightly lobed. A wide seminal receptacle is present, which lies behind the inner portion of the cirrus sac. The uterus reaches nearly to the margins of the proglottids when fully developed. It is constricted noticeably in the regions of the unusually large lateral excretory vessels. The eggs are elongated in shape and have rounded ends (Fig. 17). The outer shell varies from 63 to  $87\mu$  in length and 13 to  $20\mu$  in width, the inner from 49 to  $63\mu$  in length and 8 to  $12\mu$  in width. The embryo varies from 27 to  $36\mu$  long and is but little narrower than the inner shell in width.

The muscles are fairly well developed, and are placed as indicated in figure 19. The longitudinal excretory vessels consist of one very large and one small vessel on each side as is shown in the same diagram of a cross section (Fig. 19).

The size of the hooks of this species is intermediate between that of *D. parviceps* and *D. inflata*. Also the structure of the protruded cirrus is very decidedly different from any other species.

*Diorchis microcirrosa* n. sp.

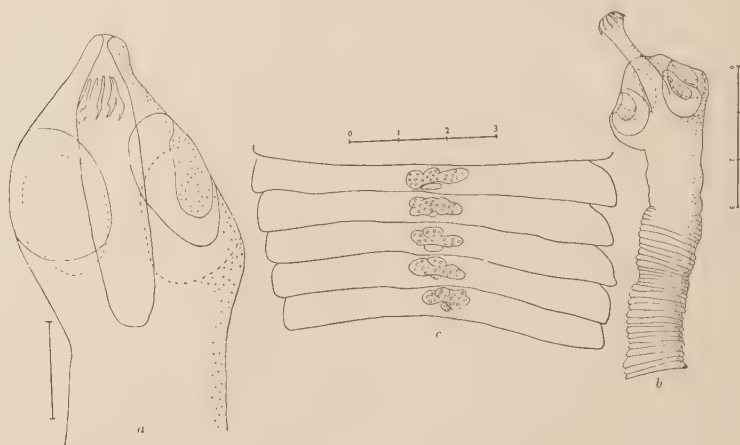
The following described specimens were obtained by Mr. L. B. Dickey at Buffalo Lake, N. D., on September 19, 1919. The host was the blue-winged teal, *Querquedula discors* (Linn.). They are catalogued in the author's collection under the host number 613a.

The worms are all rather strongly contracted, and, in this condition, specimens with gravid proglottids measure from 25 to 33 mm. in length and about 0.75 mm. in maximum width. The scolex measures approximately 0.25 mm. in width, and is followed by a short neck region (Textfig. B). The rostellum carries a single row of 10 hooks, which measure from 29 to  $32\mu$  in length, and are shaped as indicated in figure 25.

The two centrally placed testes are usually close together and vary considerably in size (Fig. 23). The cirrus sac reaches to the center of the proglottid, and contains a large internal seminal vesicle. Only a few cirri have been found which are believed to be fully everted. They are small, extending but 12 to  $15\mu$  beyond the genital pore, and have a bulb-like enlargement  $5\mu$  in diameter in their central portion (Fig. 21). The pore is in the anterior fourth of the margin of the proglottid. An external seminal vesicle is located near the inner end of the cirrus sac

(Fig. 22). Both vagina and cirrus sac lie dorsal to the longitudinal excretory vessels.

The ovary is to be found in the center of the proglottid and is variable in shape (Textfig. C). In a few proglottids it is very much reduced in size, and in some appears to be entirely absent. There is a large seminal receptacle between the excretory vessels and cirrus sac. The vitelline gland is to be found directly behind the ovary. The uterus is sac-like and rarely lobed. The eggs are, at first, spherical but become elongated as they mature. They have the two shells typical of *Diorchis* eggs. The outer shell varies from  $65$  to  $80\mu$  in length and  $12$  to  $19\mu$  in width, and the inner from  $50$  to  $58\mu$  in length, and from  $8$  to  $12\mu$  in width. Very slender hooks can be made out on some of the embryos with a 1.9 oil immersion objective. The eggs differ some-



Text figure.—A, *Diorchis spinata*, scolex with retracted rostellum; B, *Diorchis microcirrosa*, scolex with protruded rostellum; C, *D. microcirrosa*, outline of five proglottids showing position and shape of ovary and vitelline gland.

what in shape at their ends, some being more pointed than others (Fig. 24). It is possible that this is due to shrinkage during the process of preparation.

The muscles are very well developed in this species, the longitudinal bundles being easily made out in whole mounts. In cross section the fibers are seen to be numerous. The longitudinal excretory vessels also are shown in figure 22. No transverse vessels were observed.

This species differs from *Diorchis kodonoides*, also from the blue-winged teal, in its much smaller size, the smaller size of the hooks and the structure of the cirrus. *Diorchis acuminata* has hooks only slightly larger but different in shape and size. *Diorchis americana* has hooks about twice as long and quite different in shape.



BRIEF DIAGNOSIS OF THE SPECIES OF THE GENUS *DIORCHIS*

Species with hooks 65 to 70 $\mu$  in length:

*D. americana* Ransom 1909

Host: Coot, *Fulica americana*. Locality: North America. Length of specimens with gravid proglottids 20 to 25 mm. Maximum width, 0.6 mm. Hooks, 65 $\mu$  long. Cirrus very slender, 1.5 to 2 $\mu$  in diameter, without bulbous enlargement and unarmed. Fully extended cirrus, 100 $\mu$  long. Fully developed eggs are unknown. (Ransom 1909: 48.)

*D. flavescens* (Kreffft) 1871

Hosts: Black Duck, *Anas superciliosa*; Blue wing shoveller, *Spatula rhynchotis*; teal, *Nettion castaneum*; and the white-eyed duck, *Aythya australis*. Locality: Australia. Length: 3 to 8.4 cm. Maximum width: 1 mm. Hooks, 68 $\mu$  long. Cirrus: Long, slender, 0.5 by 0.0054 mm., of uniform diameter, with minute armature. (Kreffft, 1871: 219; Johnston 1912: 15.)

*D. bulbodes* Mayhew 1929.

See this paper.

Species with hooks 26 to 48 $\mu$  in length:

*D. acuminata* (Clerc) 1902

Hosts: European teal, *Nettion crecca*; gadwall, *Chauliasmus streperus*; European coot, *Fulica atra*; coot, *Fulica americana*; European Widgeon, *Mareca penelope*. Locality: Europe, North America. Length of immature specimens, 35 to 45 mm. Width: 0.65 mm. Hooks, 38 $\mu$  long. Cirrus: 150 $\mu$  long and 6 to 8 $\mu$  in diameter with a globular enlargement at base 14 to 16 $\mu$  in diameter. (Clerc 1903: 281; Ransom 1909: 42; also this paper.)

Specimens of *Diorchis acuminata* in the author's collection under the host number of 252a show a very minute armature of blunt spines under a  $\frac{1}{12}$  oil immersion objective. Figure 26 represented the cirrus of this species.

*D. excentricus* Mayhew 1925

Host: Ruddy duck, *Erismatura jamaicensis*. Locality: United States. Length of immature specimens, 26 to 52 mm. Maximum width, 1.4 mm. Hooks, 26 to 31 $\mu$  long. Cirrus when fully extended, 0.08 to 0.1 mm long, with a small bulbular enlargement along the proximal  $\frac{1}{4}$  to  $\frac{1}{3}$  of its length, and set with numerous small spines throughout its entire length. (Fig. 27.) (Mayhew 1925: 90.)

A study of some specimens of *Diorchis excentricus* in addition to those forming the basis of the description in Mayhew 1925 shows that the reproductive organs may vary from lateral as originally described to median in position.

*D. microcirrosa* Mayhew 1929

See this paper.

*D. spinata* Mayhew 1929

See this paper.

Species with hooks from 12 to 23 $\mu$  in length.

*D. parviceps* (von Linstow) 1872

Host: Red-breasted merganser, *Mergus serrator*. Locality: Europe. Length: 110 mm. Maximum width: 2.16 mm. Hooks, 12 $\mu$  long. This cirrus is described by von Linstow as follows: "Die Cirren werden bis 0.11 mm. weit vorgestreckt; sie sind am Ende kolbenförmig verdickt und hier 0.031 mm. breit; sie sind bedornt und erscheinen bald vorgestülpt, bald handschuhfingerartig zurückgezogen." (von Linstow 1872; and 1904: 306-307.)

*D. inflata* (Rudolphi) 1809

Hosts: European coot, *Fulica atra*. Locality: Europe. Length, 80 to 100 mm. Width: 2 to 3 mm. Hooks, 23 $\mu$  long according to Jacobi. Cirrus long and slender with bulb at base and unarmed. Eggs elongated, outer shell, 37 to 41 $\mu$  in diameter and the embryo 17 $\mu$  in diameter. (Jacobi 1898: 95-105, Clerc 1903: 284 and von Linstow 1906: 15-17.)

*D. kodonoides* Mayhew 1929

See this paper.

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## EXPLANATION OF PLATE XXI

*sr*, seminal receptacle; *cs*, cirrus sac; *sv*, seminal vesicle. Scale equals 0.1 mm. in figures 1, 3, 6, 7, 8, 9, 10, 11, 15, 16, 19, 22, and 0.01 mm. in 2, 4, 5, 12, 13, 14, 17, 18, 20, 21, 24, 25, 26, 27.

Fig. 1.—*Diorchis spinata*, cross section of a proglottid in the region of the pore. 2. Egg. 3. Three proglottids with well developed reproductive organs. 4. Cirrus fully extruded. 5. Hook. 6. Two proglottids with well developed male reproductive organs.

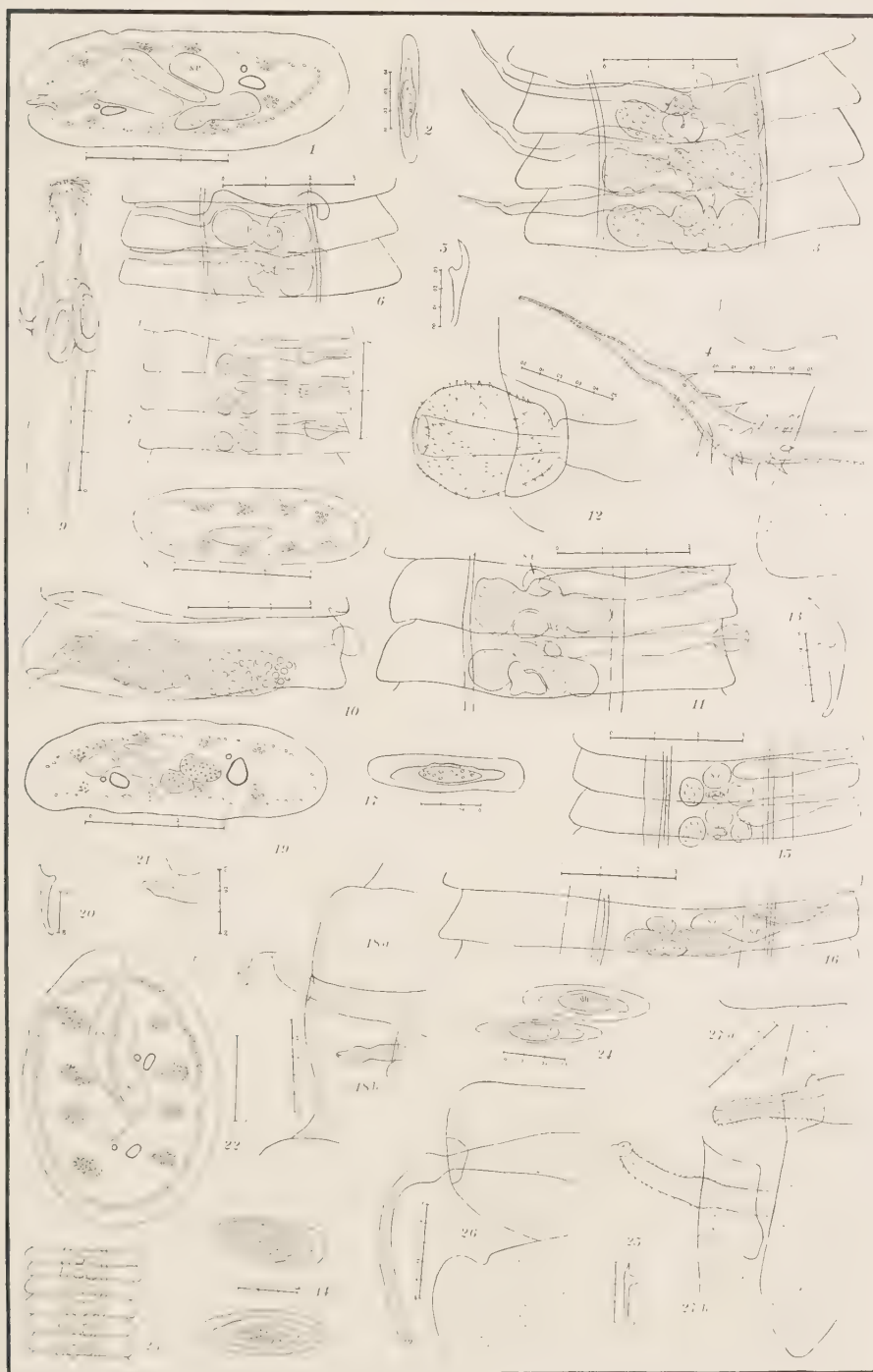
Fig. 7.—*Diorchis bulbodes*, three proglottids showing male reproductive organs. 8. Cross section of proglottid showing arrangement of muscles. 9. Scolex with protruded rostellum. 10. Proglottid showing uterus well developed. 11. Two proglottids with well developed female reproductive organs. 12. Cirrus showing shape and armature. 13. Hook. 14. Two eggs showing difference in shape.

Fig. 15.—*Diorchis kodonoides*, two proglottids showing well developed male reproductive organs. 16. Proglottid showing well developed female reproductive organs. 17. Egg. 18a. Fully protruded cirrus. 18b. Partially protruded cirrus. 19. Cross section of proglottid showing arrangement of muscles and excretory vessels. 20. Hook.

Fig. 21.—*Diorchis microcirrosa*, protruded cirrus. 22. Cross section of the proglottid showing muscles and excretory vessels. 23. Six proglottids showing position and variation in size and testes. 24. Two eggs showing variation in shape. 25. Hook.

Fig. 26.—*Diorchis acuminate*, showing protruded cirrus.

Fig. 27a.—*Diorchis excentrica*, showing protruded cirrus. 27b. Partially protruded cirrus.







THE EXCRETORY SYSTEM OF CRYPTOCOTYLE  
(HETEROPHYIDAE) \*

HORACE W. STUNKARD

Knowledge of the excretory system of adult trematodes is confined to the description of only a few species, most of them worked out by that eminent helminthologist, Arthur Looss. His researches demonstrated the importance of the system but the study is so difficult and tedious that few later workers have undertaken it. Cort, Faust, Sewell, Miller, and others have made extensive studies on the excretory system in cercariae, but the flame cell pattern of postcercarial stages remains almost unknown. During the summer of 1927, it was possible to work out the morphology of the excretory system and flame cell pattern of the species of *Cryptocotyle* whose metacercarial stages occur encysted in the fins and gills of the cunner, *Tautoglabrus adspersus*, at Woods Hole, Mass.

The species in question was identified as *Tocotrema lingua* (Creplin) [Syn. *Cryptocotyle lingua*] by Linton (1915). According to Ciurea (1924) it is not identical with *C. lingua* of Europe and for it he proposed the name *C. americana*. Ciurea arrived at this opinion after comparison of American specimens of *Cryptocotyle* from *Phoca vitulina* with European specimens of *C. lingua* taken from *Larus argentatus* and from the dog. The two species were distinguished by differences in size, in the location of the bifurcation of the alimentary tract, and in the anterior limits of the vitellaria. In *C. americana* the length varies between 0.55 and 1.52 mm., the bifurcation is midway between the oral and ventral suckers, and the vitellaria terminate midway between the bifurcation and the acetabulum, whereas in *C. lingua* the length varies between 0.95 and 2 mm., the bifurcation is farther anterior, and the vitellaria extend forward almost to the bifurcation.

Specimens found at Woods Hole, Mass., as natural parasites of birds, and others developed experimentally in the intestine of cats and white rats, measure from 0.75 to 1.5 mm. in length. The vitellaria extend only about halfway from the acetabulum to the bifurcation of the alimentary tract. In these respects the specimens agree with Ciurea's definition of *C. americana*. The esophagus, however, is short and the bifurcation is situated one-third to one fourth of the distance from the oral sucker to the acetabulum.

In twenty specimens from the cat, measurements of the regions utilized by Ciurea in specific determination vary as follows: the distance from the oral sucker to the bifurcation 0.13 to 0.197 mm.; from the

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\* Contribution from the Biological Laboratory, New York University.

bifurcation to the acetabulum 0.23 to 0.395 mm., and from the anterior limits of the vitellaria to the acetabulum 0.08 to 0.23 mm. Corresponding measurements of ten specimens from the rat are: oral sucker to bifurcation 0.07 to 0.1 mm.; bifurcation to acetabulum 0.165 to 0.36 mm.; and from the anterior limits of the vitellaria to the acetabulum 0.09 to 0.165 mm. Ten specimens from *Larus argentatus* gave the following measurements: oral sucker to bifurcation 0.08 to 0.136 mm.; bifurcation to acetabulum, 0.18 to 0.368 mm.; anterior limits of the vitellaria to the acetabulum 0.07 to 0.13 mm. These measurements portray the amount of variation found in this region of the body and since all are sexually mature specimens, subjected to the same technique, the figures are truly comparative.

Examination of these data shows that the specimens agree with *C. lingua* in size and in position of the bifurcation, but differ from the description of that species in the extent of the vitellaria. This last feature, moreover, is subject to much variation and differs with the degree of sexual maturity of any given worm. The specimens agree with Ciurea's description of *C. americana* in size and extent of vitellaria but differ from it in location of the bifurcation of the alimentary tract. Ciurea's two species overlap in size to such an extent, however, that specimens cannot be assigned to one or the other on the basis of size alone.

Supplementing the study of specimens collected at Woods Hole, I had opportunity, through the kindness of Dr. M. C. Hall, to examine all of the specimens of *C. lingua* from American sources in the collection of the U. S. National Museum. This material included specimens from *Vulpes lagopus*, *V. fusca*, *Phoca vitulina*, and from the dog, as well as specimens from *Larus argentatus*, *L. atricilla*, *L. delawarensis*, and from *Gavia immer*. The worms manifest considerable variation in size and in morphology. Those from the dog and fox are slightly larger than those from the birds and one of those from *V. fusca* measures 2 mm. in length. The extent of the vitellaria and position of the bifurcation of the alimentary tract are subject to the same variation as those collected at Woods Hole. Among the specimens from *Phoca vitulina* there is one in which the bifurcation is about midway between the oral sucker and the acetabulum but there are others in which the bifurcation is not more than one-fourth of the distance from the oral sucker. Since the morphological features designated by Ciurea for separation of species are not constant, it appears that the two species are not distinct and that *C. americana* should be suppressed as a synonym of *C. lingua*. Consequently, in agreement with the determinations of Linton (1915, 1928) and Ransom (1920), the specimens are referred to *C. lingua* (Creplin) Fischöeder.

## DESCRIPTION

When freed from their cysts the metacercariae measure from 0.44 to 0.7 mm in length and from 0.15 to 0.21 mm. in diameter. They are about one-half as long as fully mature worms. In the metacercarial stage the portion of the body anterior to the genital pore is slightly more than twice as long as the region behind the pore, whereas in the adult condition the genital pore is not far from the middle of the body. The preacetabular portion of the body increases in length only 25 to 50 per cent after emergence from the cyst, and the essential morphological difference between the metacercaria and the adult consists in a smaller postacetabular region of the former due to the undeveloped condition of the reproductive organs. Since there is so little growth, other than that associated with the maturity of the sexual organs, and since maturity is attained in about a week after emergence, it appears probable that the excretory system of the metacercaria is very similar if not precisely like that of the adult worm. Such an interpretation is not without precedent since Cort (1919) believes that the excretory system of *Cercaria polyadena* has reached its full development in number and arrangement of flame cells.

The undeveloped condition of the reproductive organs in the metacercaria permits a study of the details of the excretory system which would be virtually impossible in a fully mature and gravid worm. The present study was made entirely on living specimens, examined under a 2 mm. oil immersion objective. Although over one hundred worms were mounted and studied, the specimen reproduced (Fig. 1) was one of three in which the entire system was observed. Parts of the system were worked out in each of the other mounts and the portions observed agree with those shown in the figure. As announced in a preliminary communication (Stunkard 1927), the normal flame cell formula for the metacercaria is  $2 \times (3 + 7 + 7) + (7 + 7 + 7)$ . The form of the excretory vesicle, the course of the collecting ducts, the manner of branching in the system, the position of the subdivisions, and the location of the flame cells are shown in figure 1.

The excretory pore is terminal, surrounded by a strong sphincter. The vesicle passes forward between the testes. Due to the position of these organs which lie on opposite sides of the median plane, the testis of the right side obliquely behind that of the left, the course of the vesicle is somewhat sinuous. Anterior to the testes the vesicle divides into two limbs which form a curve extending diagonally across the body. The right limb is short whereas the left is longer and passes further anteriorly. The posterior and antero-lateral portions of the vesicle are ciliated. From the antero-lateral portions of the vesicle the primary collecting ducts pass forward on the median sides of the digestive ceca. At or near the level of the genital sinus the ducts cross the ceca and

continue anteriorly on the lateral sides of these structures. About midway between the genital pore and the pharynx each of the common collecting ducts divides to form an anterior collecting duct and a posterior collecting duct.

The anterior duct continues forward to the region between the bifurcation of the alimentary tract and the pharynx where it turns laterad and caudad to form a loop as shown in the figure of Jägerskiöld (1899). From the lateral limb of the loop a short secondary or accessory collecting tubule passes laterad and divides into anterior and posterior branches. The anterior stem by repeated alternate branching gives rise to three capillaries, each of which ends in a flame cell. The position of the flame cells is subject to considerable variation, in fact as shown in figure 1, the flame cells of the two sides may not occupy precisely opposite positions. The condition shown on the right side is more usual than that of the left. The posterior stem by repeated alternate branching gives rise to seven capillaries, each of which terminates in a flame cell. It appears from the studies of Looss and Cort on the development of the excretory system that this raceme like arrangement of the capillaries and flame cells could have been formed only by the successive subdivision of the terminal or distal cell. In the specimen shown in the figure this cluster on the right side of the body has only six flame cells but since seven is the number ordinarily found in the many worms examined, it appears probable that the terminal cell had for some reason failed to undergo the final division. The cluster of flame cells just described drains the portion of the body immediately anterior to the bifurcation of the common collecting duct. From the terminal portion of the anterior collecting duct a secondary or accessory tubule passes backward, and a short distance behind the bifurcation of the common collecting duct, it gives rise to a third cluster of flame cells, seven in number and arranged in the same alternate manner. This cluster supplies the region of the body between the bifurcation of the common collecting duct and the genital pore. The anterior collecting duct thus receives excretory waste from three clusters of flame cells.

The posterior collecting duct extends backward along the lateral face of the common duct to the level of the genital pore where it gives off a branch. This accessory tubule continues backward, dividing alternately to terminate in seven flame cells which serve the region between the level of the genital sinus and the ovary. At the proximal end of the accessory tubule from the cluster of cells just described, the posterior collecting duct continues as a secondary tubule to the level of the excretory vesicle where it divides to form a cluster of seven flame cells draining the region of the vesicle and the testes, and another cluster of seven flame cells supplying the posttesticular portion of the body. In each of the clusters, while not entirely constant, the successive cells tend to be alternately dorsal and ventral in position.

## DISCUSSION

Since the studies of Looss it has been generally accepted that the excretory system of the trematodes is of the greatest importance in determining genetic relationships of these worms. Homologies between the excretory systems of cercariae have been employed not only to relate them to one another but also to assign them to various generic and family groups. Cort (1919) states, "The excretory system is so conservative that the '2-3-6' type and its derivatives may represent a character surmounting family limits, as is suggested by the present classification of the forms exhibiting this peculiarity." Sewell (1922), while recognizing the importance of the excretory system in morphological and taxonomic studies, cautions against too hasty generalization since "in the vast majority of cases any attempt in the present state of our knowledge to relate cercarial groups to genera or families of adults must largely be a matter of guess work," and again, "The classification of larval trematodes cannot be based on any one morphological system or group of characters, but must include a study of their development, as well as the morphology of both parent and offspring." Faust (1924) however believes "that there is only one common system carried over from the cercaria to the adult, which is sufficiently definite and conservative as to be utilizable for purposes of group identification. That system is the excretory system. The more work that is done in this system, the more indicative is it of possessing value as a natural basis of classification, and the more evident is the artificiality of some of Lühe's groupings of larval forms and of the equal artificiality of some of the families of adult trematodes that have been created. While the study of adult correlations with known larval forms is still in its infancy, it is not too much to state that all members of a natural adult group possess the same basic excretory pattern." Miller (1926) while stressing the importance of the excretory system in the determination of relationship, argued against the principle adopted by Faust, of basing conclusions entirely on a single organ system. In fact, Miller finds that certain of Faust's groups are not homogeneous and questions the truth of the assumption that the development of the excretory system proceeds through regular divisions of the flame cells of the larva, since certain cells may divide more rapidly or more slowly than others. Miller, consequently, attempted to correlate data acquired from a study of all of the organ systems.

The degree of uncertainty as to how much dependence may be placed on the structure of the excretory system and on the flame cell formula makes the present paper significant. Comparison of the excretory systems of genera included in the family Heterophyidae affords an opportunity to test the idea that closely related forms always possess the same fundamental type of excretory system and that mem-



bers of a natural family have the same flame cell formula. *Cryptocotyle* is so similar to *Heterophyes* in general morphology and in life history that the two forms have always been regarded as closely related. Looss (1899) placed them in the same subfamily and Odhner (1914) included them together in the family *Heterophyidae*. Nicoll (1923) extended the limits of the family *Heterophyidae* to include the subfamilies *Microphallinae* Ward and *Gymnophallinae* Odhner. Poche (1925) added the subfamily *Haplorchinae* Looss and several previously unassigned genera. The flame cell patterns are known for three genera of the family. That of *Heterophyes* was described by Looss (1894), that of *Microphallus* by Wright (1912), and that of *Cryptocotyle* is described in the present paper. The excretory systems of *Heterophyes* and *Microphallus* as described by Looss and Wright, respectively, are shown in figures 3 and 2. *Heterophyes* has the formula  $2 \times (3 + 3) + (3 + 3)$ , *Microphallus* has the formula  $2 \times (2 + 2) + (2 + 2)$ , and *Cryptocotyle* has the formula  $2 \times (3 + 7 + 7) + (7 + 7 + 7)$ .

The excretory systems of the three genera are strikingly different. The form of the vesicle of *Microphallus* is much like that of *Heterophyes* but the common collecting ducts are very short in *Microphallus* whereas in *Heterophyes* they extend one-half of the length of the body. Similarly, the secondary tubules of the posterior flame cell groups in the anterior half of the body of *Microphallus* are very short, whereas in *Heterophyes* they are as long as the secondary tubules leading to the anterior flame cell groups. These differences in length of the components of the excretory systems in the two genera modify the appearance of the systems to a considerable extent. In the two genera the anterior and posterior collecting ducts bifurcate to give four secondary ducts and four flame cell groups on each side of the body. A very important difference, however, is found in the number of tubules and flame cells in the capillary groups. In *Heterophyes* three capillaries arise from the end of each secondary collecting duct, whereas there are but two in *Microphallus*. Although there are conspicuous differences between the excretory systems of *Heterophyes* and *Microphallus*, there are more points of resemblance between the systems in these two genera than there are between either of them and the system in *Cryptocotyle*.

The form of the excretory system in *Cryptocotyle* is notably different from that of either *Heterophyes* or *Microphallus*. In *Cryptocotyle* the stem of the vesicle is longer and the limbs are shorter, forming a Y, whereas in the other two genera the stem of the vesicle is shorter and the structure is V shaped. The division of the common collecting duct into anterior and posterior branches is similar in *Cryptocotyle* and *Heterophyes*, but the further subdivisions in *Cryptocotyle* are very different from those of either *Heterophyes* or *Microphallus*. In the

latter two genera the anterior and posterior collecting ducts bifurcate to produce four accessory collecting ducts, each of which terminates in a flame cell group, the capillaries diverging from a common locus. In *Cryptocotyle*, on the other hand, the anterior and posterior collecting ducts do not bifurcate to produce four accessory collecting ducts on each side of the body. Actually, there are six flame cell groups on each side of the body, and the manner of branching and number of flame cells is not only different from the other genera, but it differs in the anterior and posterior regions of the body. The details of these disparities are clearly shown in the figures and further statement appears unnecessary. The most important difference is found in the arrangement of the tubules and number of the flame cells in the capillary groups. In *Heterophyes* and *Microphallus* there are three and two capillaries respectively, arising from a common locus, whereas in *Cryptocotyle* there are either three or seven capillaries which alternate with more or less regularity along a central stem.

The differences that have been noted between the excretory systems of *Heterophyes*, *Microphallus*, and *Cryptocotyle* necessitate certain revisions either of current opinion or theory. Either the relationship of these genera is not so close as has been believed, and their similarities are the result of convergence, or marked differences may exist in the form of the excretory system of closely related genera. The removal of *Microphallus* from the family *Heterophyidae* may perhaps be advocated, but the exclusion of *Cryptocotyle*, I believe, will be hard to justify. There appears to be abundant evidence that *Heterophyes* and *Cryptocotyle* are closely related and every investigator who has worked on these forms has included them in the same family. Furthermore, the excretory system of *Microphallus* agrees more closely with that of *Heterophyes* than does the system in *Cryptocotyle*. If the form of the excretory system is used as the criterion for determining relationships, *Microphallus* rather than *Cryptocotyle* should be retained in the family. The striking differences in the excretory systems and flame cell formulae of genera, admittedly closely related, are subversive to the thesis that the excretory system affords the only certain basis for determining genetic relations among the trematodes and show the need for caution in the formulation of such sweeping generalizations.

#### SUMMARY

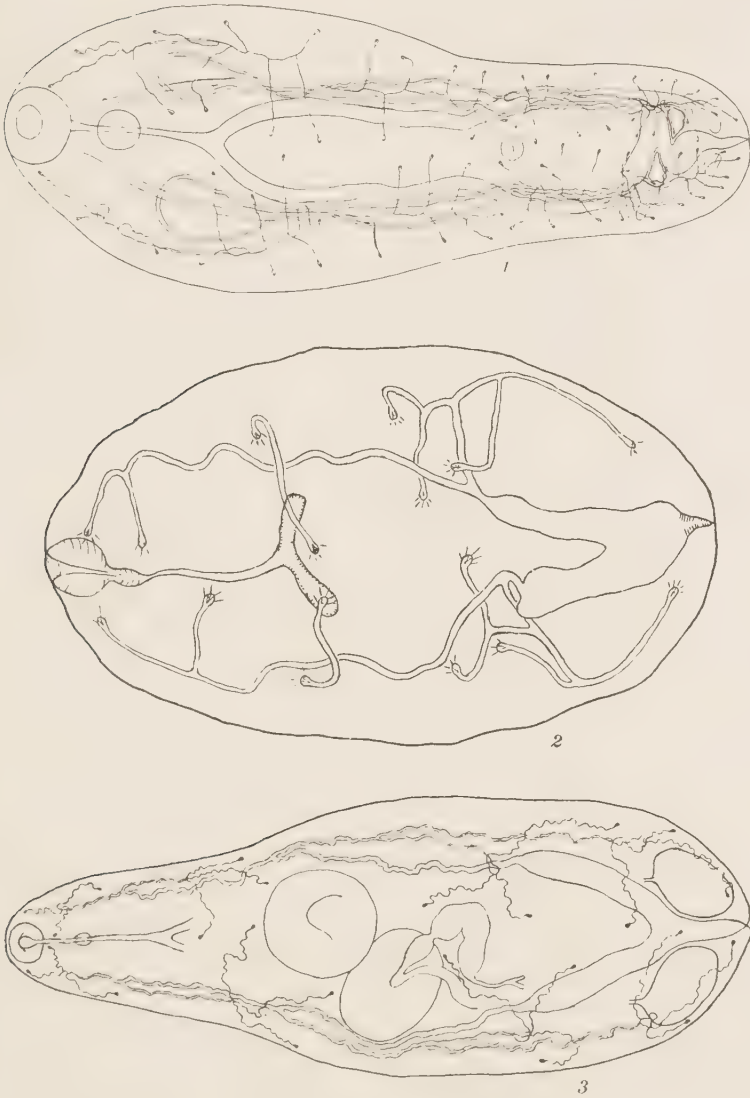
The species of *Cryptocotyle* which occurs at Woods Hole, Mass., is identified as *C. lingua*. Study of specimens from several hosts, deposited in the U. S. National Museum, and others developed in experimental animals, has demonstrated that *Cryptocotyle americana* Ciurea 1924 is a synonym of *C. lingua* (Creplin). The excretory system of *Cryptocotyle* is described and compared with that of *Heterophyes* and *Micro-*

phallus. Differences in the excretory systems of these genera, all of which have been placed in the family Heterophyidae, indicate that the flame cell formula and form of the excretory system cannot be accepted as the only basis for determining genetic relationships among the trematodes.

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STUNKARD—STRUCTURE OF CRYPTOCOTYLE



EXPLANATION OF PLATE XXII

The excretory system. Fig. 1. *Metacercaria Cryptocotyle lingua* (Dorsal View). Actual length of specimen, 0.72 mm. 2. *Heterophyes heterophyes* (After Looss 1894); 3. *Microphallus opacus* (After Wright 1912).





STUDIES ON THE TREMATODE FAMILY STRIGEIDAE  
(HOLOSTOMIDAE) NO. XIX. *DIPLOSTOMULUM*  
*SCHEURINGI* SP. NOV. AND *D. VEGRANDIS*  
(LA RUE) \*

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The purpose of this paper is to present a description of a new species of metacercaria, *Diplostomulum scheuringi*, and some observations on the morphology and behavior of *Diplostomulum vegrandis* (La Rue).

*Diplostomulum scheuringi* sp. nov.

Butler (1919) reported the occurrence of parasites, which she identified as *Diplostomulum*, in the eyes of certain fishes of Douglas Lake, Cheboygan County, Michigan. These specimens were reclassified by La Rue, Butler and Berkhout (1926:285) as *Tylodelphys* Diesing. The parasites with which these reports are concerned were collected by Miss Butler during the summers of 1918 and 1919 from the following species of fish: *Ambloplites rupestris* (Rafinesque), *Ameiurus nebulosus* (Le Sueur), *Esox lucius* (L.), *Eupomotis gibbosus* (L.), *Micropterus dolomieu* (Lacépède), *Notropis cornutus* (Mitchill), *Perca flavescens* Mitchill and *Percopsis omiscomaycus* (Walbaum). I have reexamined the specimens collected by Miss Butler from *A. rupestris*, *E. gibbosus* and *P. flavescens* and find that they represent a new species of *Diplostomulum* which I call *Diplostomulum scheuringi* in honor of Professor L. Scheuring of the Bayerische Biologische Versuchsanstalt für Fischerei of München, Germany. I select as representatives of this species specimens collected by Miss Butler from the rock bass, since this host was found to be more heavily infected than the other species examined. Out of 92 specimens of *A. rupestris* examined, 66 were parasitized with from 1 to 55 (average 8.6) worms of the present species. The incidence of infection in *P. flavescens* and *E. gibbosus* was very much lower.

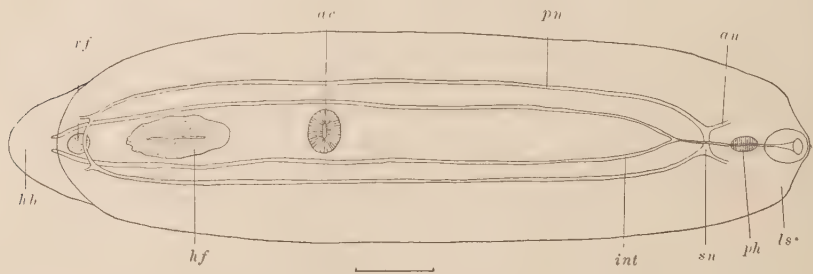
Three out of 15 *P. flavescens* from Douglas Lake, which I examined during the summer of 1927, were each found to harbor one worm apparently identical with those collected from the rock bass by Miss Butler. These specimens were studied both alive and in the preserved condition. Preserved specimens were studied in the manner outlined in the description of *Diplostomulum browni* (Hughes, 1928).

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\* Contribution from the Biological Station and from the Department of Zoölogy, University of Michigan. This is the nineteenth of a series of studies on the family Strigeidae by Professor George R. La Rue, his students and associates.

Some of these, collected by Miss Butler, are catalogued in the parasite collection of the Museum of Zoölogy of the University of Michigan as follows: type slide, specimens mounted *in toto*, No. 304; paratypes mounted in sections, Nos. 305-309; specimens from *Perca flavescens* mounted *in toto*, No. 310; specimens from *Eupomotis gibbosus* mounted *in toto*, No. 311.

*Diplostomulum scheuringi* occurs in the humors of the eye, chiefly the vitreous, apparently never in the lenses. It closely resembles *Diplostomulum clavatum* (Von Nordmann), parasitic in the eyes of certain European fishes, as described by Von Nordmann (1832:42) and *D. rhachiaeum* (Henle), parasitic in *Rana esculenta* and *R. temporaria*, as described by Henle (1833), in that the body is more than twice as long as wide, the ventral surface of the fore-body is only slightly, if at all, concave, the lateral suckers and hind-body are poorly differentiated, being visible only in certain states of muscular contraction,



TEXT FIGURE

*Diplostomulum scheuringi*, ventral view of preserved specimen, camera lucida drawing. *ac*, acetabulum; *an*, anterior nerve; *hb*, hind-body; *hf*, hold-fast organ; *int*, intestinal cecum; *ls*, rudiment of lateral sucker; *ph*, pharynx; *pn*, posterior nerve; *rf*, fundament of reproductive organs; *sn*, supra-pharyngeal nerve commissure. Scale represents 0.1 mm.

and the calcareous corpuscles are ellipsoidal. *D. scheuringi* differs, however, from either of those species because of its considerably greater size and, according to the figures of *D. clavatum* of Von Nordmann [1832: Taf. III, Figs. 5 to 8] and of *D. rhachiaeum* of Lühe [1909: Fig. 122], relatively longer esophagus. Also according to Von Nordmann's drawings the position of the acetabulum in *D. clavatum* is near or anterior to the middle of the body whereas in my specimens it is decidedly in the posterior half of the body. This difference, however, may be due to the fact that my specimens are preserved, whereas Von Nordmann studied living worms.

In general the anatomy of *D. scheuringi* is similar to that of *Diplostomulum browni* as described by Hughes (1928) and is sufficiently demonstrated in the figure. Attention, however, may be called to the

following features. The posterior nerve trunks can easily be traced back to where they are joined by a commissure posterior to the hold-fast organ. Here they give rise to a pair of nerves which probably extend into the hind-body. The pattern of the "reserve bladder" is similar to that shown for *D. browni* by Hughes (1928, Fig. 7). The calcareous corpuscles are relatively smaller, more numerous, and more widely and irregularly scattered through the parenchyma than in other eye-inhabiting species heretofore described in North America. In preserved specimens the body has a characteristic longitudinally striated appearance due to the presence of relatively large longitudinal muscle fibers. The presence of many conspicuous, dorso-ventral muscle fibers and of unicellular glands, both scattered throughout the parenchyma, is clearly visible in cross-sections.

The principal measurements of 10 preserved specimens mounted *in toto* are given in the accompanying table.

*Measurements in mm. of Ten Diplostomulum scheuringi, Mounted in Toto*

	Minimum	Maximum	Average
Body			
Length.....	0.885	1.155	1.026
Width.....	0.21	0.27	0.249
Oral sucker			
Length.....	0.036	0.045	0.041
Width.....	0.03	0.039	0.033
Acetabulum, diameter.....	0.036	0.045	0.04
Hold-fast organ			
Length.....	0.096	0.15	0.117
Width.....	0.042	0.075	0.056

#### *Diplostomulum vegrandis* (La Rue)

The original description of this species (La Rue, 1917:8) is based upon a study of preserved worms taken from specimens of *Thamnophis marciana* (Baird and Girard) and *T. eques* (Reuss) collected in western Texas in 1914. The following remarks based upon a study of living specimens are taken chiefly from an unpublished manuscript written by Professor W. W. Cort. This manuscript and some of the specimens (subsequently preserved) about which it was written have been kindly given to Professor La Rue by Professor Cort for my use. These worms (alcoholic material, lots 312a, b and c in the parasite collection, Museum of Zoology, University of Michigan) have been identified with *D. vegrandis* (La Rue) by comparison with the type specimen (slide no. 155 of the same collection).

During the summer of 1914 Professor Cort found that every specimen of a considerable number of tadpoles, *Rana pipiens* Schreber, taken from Sedge Pond, a beach pool of Douglas Lake, was infected with these parasites. The worms occurred chiefly in the muscles of the host between the fibers of which, observing with a microscope, they could

be seen moving freely. During the summer of 1927, I found a great many of these worms in several specimens of *Thamnophis sirtalis sirtalis* (L.) and *T. sauritus sauritus* (L.) collected in the vicinity of Douglas Lake. In these hosts the parasites occurred free or enclosed in delicate tissue cysts in the muscles, mesenteries and adipose tissues about the viscera. They were often particularly abundant about the anterior portions of the trachea and esophagus.

To the original description (La Rue, 1917) of this parasite I can make the following additions and corrections. The ventral surface of the fore-body is distinctly concave in living specimens. A hind-body, similar to that of *D. browni* (Hughes, 1928) is present. Lateral suckers are wanting. The entire surface of the body is covered with minute spines quincuncially arranged. Unicellular glands occur generally distributed in the parenchyma. The structure of the nervous system and the arrangement of the principal trunks of "the reserve bladder" closely resemble *D. browni*. The spheroidal calcareous corpuscles, are smaller, more numerous and more irregularly distributed than in *D. browni*. In these respects the present species resembles *D. scheuringi*. The structure, regarded by La Rue (1917: 10) as a genital pore, pertains to the hold-fast organ as suggested by Hughes (1928) and the small "irregularly triangular mass of cells" back of the hold-fast organ is the fundament of reproductive glands situated in the anterior part of the hind-body in the septum between the halves of the urinary bladder.

In locomotion the parasite after removal from the host occasionally uses the oral sucker, but seldom, if at all, the acetabulum, as an organ of attachment. The movements may consist either of alternately lengthening and shortening or flexing and straightening the body in the manner of a measuring worm. By alternately attaching the anterior and posterior edges of the fore-body by flattening them against the substratum, coordinately with these movements, spatial locomotion is accomplished. Generally the worm moves or crawls with its ventral surface facing the substratum. Flexing is accomplished by arching the body dorsally.

I wish here to express my grateful appreciation to Professor George R. La Rue by whom this study was suggested and under whom it has been conducted. I am also indebted to Professor W. W. Cort and Miss E. Priscilla Butler for specimens and data.

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## THE VIABILITY OF PARAMECIA AND EUGLENÆ IN THE DIGESTIVE TRACT OF COCKROACHES

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Experimental studies of the relations between cockroaches and protozoa have a bearing on two important problems, (1) the origin of the enteroparasitic habit of certain protozoa and (2) the possible transmission of human protozoa by cockroaches. Porter (1919) reports that the cysts of *Giardia lamblia* from man may pass unharmed through the alimentary canal of cockroaches and are then infective to white rats, but her work needs confirmation. Pessoa and Corrêa (1927) find that cysts of *Giardia lamblia* may be ingested by cockroaches and later may either be regurgitated or deposited in their feces in a living condition. It thus seems possible that cockroaches may aid in the distribution of the cysts of human protozoa, not only those of intestinal flagellates, but probably also those of intestinal amoebae. That the trophozoites of *Trichomonas hominis* do not succeed in passing through the cockroach alive seems to have been definitely proved by the experiments of the writer (Hegner, 1928). Fecal material containing these organisms was readily ingested, but most of the trichomonads were killed before they reached the stomach, within from two to five and one-half hours. Movement of material through the digestive tract of the cockroach is so slow that the chances of trichomonads being passed in a viable condition in the feces are very slight.

The problem of the origin of the enteroparasitic habit of certain protozoa is a difficult one, but data of interest may be obtained by feeding free-living protozoa to various laboratory animals and determining their viability during their progress through the alimentary canal. So far as I am aware the cockroach has been used in experiments of this type only by Cleveland (1927). He discovered living, active paramecia in the stomach (crop?) of 3 cockroaches about 2 hours after the insects had been collected, but could find only the remains of paramecia in 2 specimens about 5 or 6 hours later. Cockroaches were starved, then given a rich culture of paramecia and killed and dissected at intervals. Few, if any, of the paramecia were killed during the first 2 hours after ingestion but all were destroyed by the end of 5 hours except in one specimen in which 3 paramecia were still alive at the end of 6 hours. Cleveland concludes that the cockroaches in which the paramecia were first found had fed on water containing paramecia shortly before being brought into the laboratory.

Cockroaches serve as hosts for a considerable number of intestinal protozoa. Among these are several ciliates, *Balantidium blattarum* and *Nyctotherus ovalis*, that resemble free-living ciliates, such as *Paramecium caudatum*, in many respects. Three species of amoebae have been described from cockroaches, the large *Endamoeba blattae*, and two smaller species recently named by Lucas (1928) *Entamoeba thomsoni* and *Endolimax blattae*. Among the flagellates of cockroaches are *Lophomonas blattarum* and *L. striata*, *Trichomastix orthopterorum* and *Hexamita periplanetae*. Several species of gregarines are also known to live in these insects. The most reasonable hypothesis to account for the presence of these protozoa within the alimentary canal of the cockroach is that their ancestors were free-living protozoa that were ingested with the food or drink of the insects and were able to maintain themselves in the intestinal environment there encountered. The close resemblance of certain of the protozoa of the cockroach, especially the ciliates, to free-living protozoa is certainly an argument in favor of this hypothesis.

Two types of protozoa have been used in the experiments described below, (1) paramecia and (2) euglenae. The behavior of euglenae in the alimentary canal of the cockroach is of interest because a number of parasitic species of the Euglenoidina have been described. The writer (Hegner, 1923) has shown that a euglenoid flagellate, *Euglenomorpha hegneri*, lives in the intestine of frog and toad tadpoles and that free-living euglenae are able to live and reproduce in the living bladders of the bladderwort, *Utricularia*, whereas paramecia and certain other species are quickly killed (Hegner, 1926). Thus euglenae seem to be able to withstand digestive fluids better than certain other free-living protozoa and hence furnish favorable material for experimental work.

Twenty-three adult, winged cockroaches of the species *Periplaneta americana* were used in these experiments. The euglenae in a well-stocked culture were concentrated by centrifugation and fed to the insects with a fine pipette. The cockroaches were killed and examined at intervals of 15 or 30 minutes from one hour to 6 hours after being fed. The results are similar in many respects to those obtained in the experiments with *Trichomonas hominis*. Living specimens of euglenae were found in the crop as long as 5 hours after ingestion. Euglenae in an active condition were recovered from the stomach from one and one-half hours to 6 hours after ingestion. Most of the euglenae, however, were quickly killed in the crop and although large numbers of them were passed on to the stomach the majority of them were dead and many of them had already disintegrated, as indicated by the large numbers of chromatophores contained in the stomach material. The contents of the crop are in a fluid condition but those of the stomach are packed together in such a rigid mass that only with

difficulty are they broken apart for purposes of examination. Active locomotion is thus practically impossible for euglenae in the stomach. The living specimens recorded from the stomach several hours after ingestion may, of course, represent recent arrivals from the crop. In only 2 instances were euglenae found in the intestine; one apparently dead specimen was noted in a cockroach 5 hours and 40 minutes after ingestion and a few dead specimens in an insect 6 hours after ingestion.

These experiments prove that some specimens of free-living euglenae are able to withstand conditions in the crop of the cockroach for a considerable period (up to 5 hours) and may be passed on to the stomach in a viable state (up to 6 hours). They indicate, however, that the majority of them are usually killed in the crop within 2 hours; that very few reach the stomach in a living condition; and that an

*Table Indicating the Length of Time Paramecia Remained Alive in the Crop of 46 Cockroaches. The Time Intervals Are Given from the Ingestion of the Paramecia to the Dissection of the Cockroach*

Time Interval in Hours and Minutes	Number of Cockroaches in Which Living Paramecia Were Found	Number of Cockroaches in Which No Living Paramecia Were Found
0 30.....	3	
0 45.....	1	1
1.....	3	5
1 15.....	..	2
1 30.....	4	
1 45.....	..	1
2.....	1	11
3.....	1	
3 30.....	..	3
4.....	..	5
6.....	1	
6 30.....	1	
24.....	1	2
	16	30

even smaller number enter the intestine before disintegration. It therefore seems probable that euglenae are unable to grow and reproduce in the intestine of the cockroach and cannot pass entirely through the digestive tract and out in the feces in a living condition because of the unfavorable environment and the slow progress of material through the crop, stomach and intestine of this insect.

The experiments with paramecia were carried out just as were those with euglenae. Rich culture material was centrifuged so as to concentrate the paramecia and this was then fed by means of a fine pipette to cockroaches that had been deprived of food and water for several days. Forty-six cockroaches were fed in this way and examined at intervals of from 30 minutes to 24 hours. As the accompanying table shows, living paramecia were recovered from the crop of one specimen at the end of 24 hours and from the crop of others at intervals of from one-half to six and one-half hours. In 30 of the 46 cockroaches all of the paramecia in the crop were dead and in various stages of

disintegration and in all cases where living paramecia were recovered many killed and disintegrating specimens also occurred. In no case were paramecia recovered from the stomach alive and seldom could their remains be distinguished. Ten of the cockroaches were placed in a refrigerator at 0° C. after being fed but paramecia were killed in as many of these as in insects kept at room temperature (about 20° C.). Ten cockroaches were placed in a dish containing a watch glass full of a rich culture of paramecia. They were examined at the end of 18 hours but no paramecia were found in them.

These experiments indicate that the trophozoites of paramecium and euglena probably do not succeed in reaching the rectum of the cockroach in which parasitic flagellates and ciliates are normally to be found. It seems probable, therefore, that the trophozoites of other free-living protozoa suffer a like fate and that colonization of the rectum of these insects must have taken place by the ingestion of cysts capable of resisting conditions in the crop, stomach and intestine.

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ON *HALOCERCUS PINGI* N. SP. A LUNG-WORM FROM  
THE PORPOISE, *NEOMERIS PHOCOENOIDES*\*

HSIEN WEN WU

Since Baylis and Daubney's paper appeared in 1925, no new species has been added to the genus *Halocercus*. These authors mentioned three species none of which resembles the animal I am describing. I therefore establish a new species which I have the pleasure of naming after Professor C. Ping, Director of the Biological Laboratory, Science Society of China, Nanking, and also Professor of Zoology at this University. The genus *Halocercus* Baylis and Daubney, 1925, is well described in Yorke and Maplestone (1926).

*Halocercus pingi* sp. nov.

The worm occurs in the lung of the common Chinese porpoise, *Neomeris phocoenoides*. It is gray in color, the intestine forming a somewhat dark line during life. The male is 150 to 183 mm. and the female 255 to 364 mm. in length. The maximum thickness of the body is 0.45 to 0.6 mm. in the male and 0.55 to 0.68 mm. in the female. In the greater part of the body the cuticula is smooth. The anterior end in both sexes and the posterior region of the female show a series of circular rings in the cuticula. The posterior end of the male has no inflated cuticula. As I took every care in the preservation of my specimens, it is not very probable that the rings in the cuticula are simply due to some shrinking. Baylis also mentions similar rings in *H. lagenorhynchi*.

The six cephalic papillae are more or less distinct; the mouth opening round; the cylindrical esophagus extremely short, 0.19 to 0.22 mm. long, 0.035 to 0.039 mm. thick. The nerve ring is situated slightly posterior to the middle of the esophagus. In the anterior part of the body cavity there are two very large, unicellular glands about 5 to 7 times longer than the esophagus. These glands open so far as I could make out, into the most posterior part of the esophagus. In some specimens one of the glands appears to be twined around the intestine.

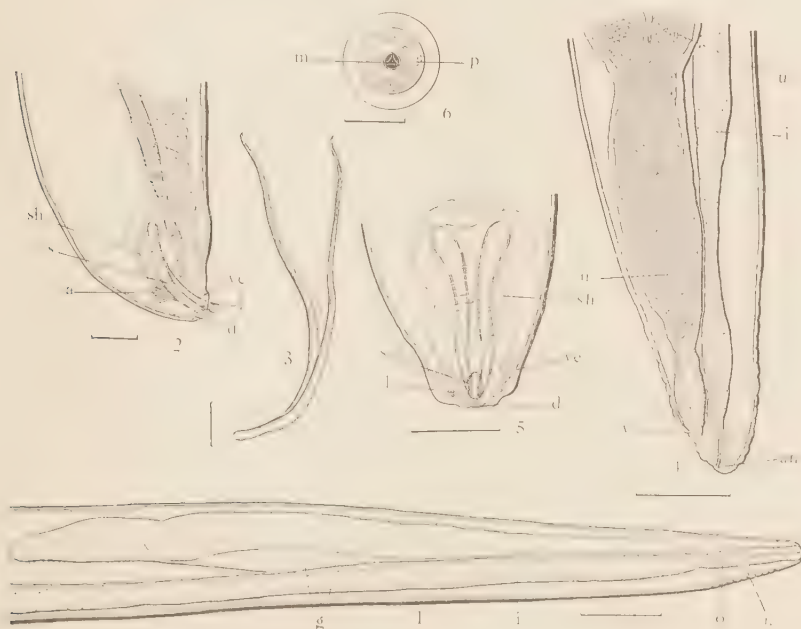
The bursa is disc-like, with the margin slightly curved between the rays. The thin cuticular part of the bursa is not distinguishable from the general cuticula. The lateral rays have double papillae and the ventral ones have pedunculate terminations. The spicules are long and slender, 0.77 to 0.82 mm. in length and are enclosed in a well-marked sheath. The thin alate parts of the spicules extend nearly to the tips. The accessory piece is rope-like with a triple coil. The male genital tube

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\*From the Parasitological Laboratory of the University of Amoy, Amoy, China.



is single, commencing a short distance behind the bases of the great glands of the anterior end. The posterior end of the female is somewhat obtuse. The anus is located a little ventral to the tip of the tail. The rectum is not clearly differentiated from the hind gut. The vulva has thick musculature opening at a short distance in front of the anus, its distance from the posterior end is 0.07 to 0.1 mm. The combined length of the vagina and common trunk of uterus is 0.65 to 0.87 mm. *H. pingi* seems to be viviparous because in my specimens the uterus always contains larvae in large numbers.



Text-figure 1, anterior end of male; 2, posterior end of male, lateral view; 3, spicules; 4, posterior end of female, lateral view; 5, posterior end of male, ventral view; 6, head, front view, mouth opening.

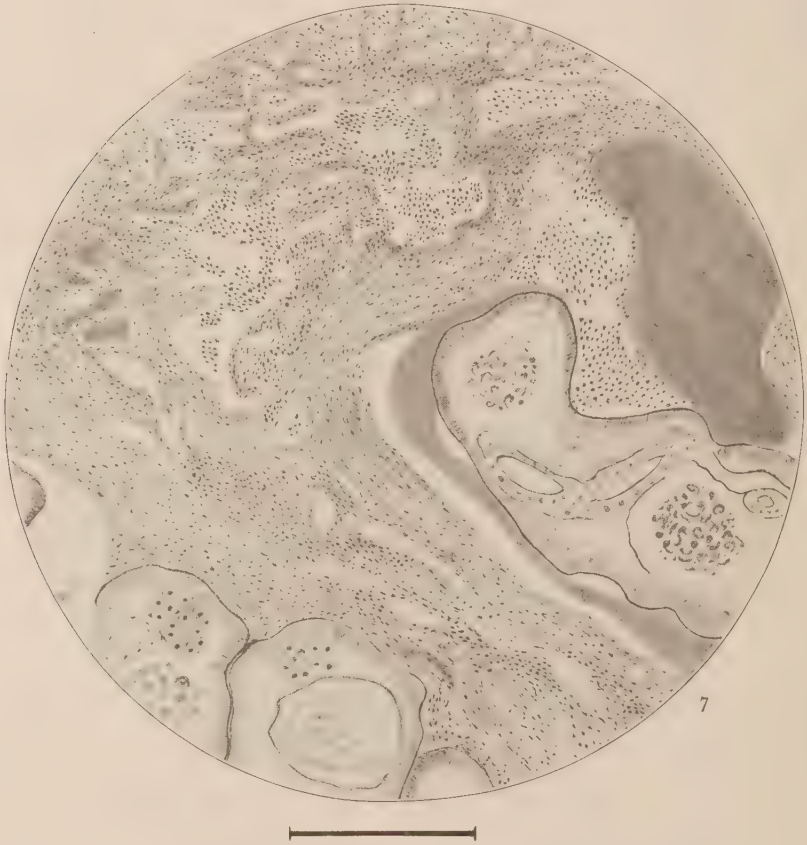
Scale represents 0.02 mm., except that on figure 5 represents .01 mm.

a, accessory piece	l, lateral ray	sh, sheath of spicules
an, anus	n, nerve ring	u, uterus
d, dorsal ray	o, esophagus	v, vulva
g, glands	p, cephalic papilla	ve, ventral ray
i, intestine	s, spicule	

#### COMPARISONS WITH RELATED SPECIES AND BIOLOGICAL DATA

There are well-marked differences between the new species and *H. delphini* Baylis and Daubney, 1925 and *H. gymnuris* (Railliet, 1899), a discussion of these differences seems unnecessary. *H. pingi* is nearly related only to *H. lagenorhynchi* Baylis and Daubney which

differs from the new species as follows: The new species has two very large glands at the anterior end which are so conspicuous that they can not be overlooked. The presence of these glands may perhaps justify placing the new species later in a new genus. *H. pingi* is doubtless very much longer than *H. lagenorhynchi* even if one considers that Baylis had only fragments of the animal for study. *H. pingi* has the accessory



Text-figure 7. Section of the lung of the host, showing worm in cavities and desquamations within alveoli.

piece in triple coil instead of double fold as is the case in *H. lagenorhynchi*. In the latter the cuticula is inflated at the posterior end of the male and this peculiarity is absent in the new species. The nerve ring of the new species has a more posterior position than that of *H. lagenorhynchi*.

In sections through the parasitised part of the lung one finds a number of worms lying close to each other in large cavities within the

lung tissue. These cavities contain besides the parasites a liquid which is coagulated by the fixation and stains pinkish red with eosin. Distributed in such coagulated masses and between the bodies of the worms are desquamated cells chiefly of the epithelial type together with polynuclear leukocytes. The cavities are surrounded by a wall formed partly by compressed lung tissue but chiefly by layers of connective tissue. The fibers of this connective tissue are mostly arranged parallel to the surface of the cavity whereas in the outer layers of this wall the fibers and the protoplasm show the ordinary type of connective tissue. One recognizes in the innermost layers a more homogeneous, finely granulated protoplasm. The inner zone shows a slight infiltration with polynuclear leukocytes. Eosinophiles are likewise present within the wall of the cavities and the neighboring lung tissue. These eosinophiles are as a whole not numerous; only in a few places within the wall of the cavity do they occur in a greater number.

The lung tissue in the neighborhood of the cavities is more or less compressed. The alveoli which are farther distance from them show a marked desquamation of the epithelial cells. Some of these isolated epithelial cells are loaded with yellow brownish pigment. I found also a marked edema in various parts of the lung, but it is difficult to say whether this is due to the parasite or not. The fluid seems a little different from that of the coagulated masses within the cavities as it is less stained by eosin. The wall is not very strong and at some places the cavities may be in open communication with the bronchial system, so that mucous or other liquid substances may enter them. The question may remain open whether the great amount of liquid within the cavities around the worms has something to do with the secretion of the glands in the anterior end of the worm.

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## NOTES

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### AMENDMENTS TO THE INTERNATIONAL RULES OF ZOOLOGICAL NOMENCLATURE

Upon unanimous recommendation by the International Commission on Zoological nomenclature, the International Zoological Congress which met at Budapest, Hungary, September 4-9, 1927, adopted a very important amendment to article 25 (Law of Priority) which makes this article, as amended, read as follows (*italicized type represents the amendment; roman type represents the old wording*):

ARTICLE 25. The valid name of a genus or species can be only that name under which it was first designated on the condition—

(a) That (*prior to January 1, 1931*) this name was published and accompanied by an indication, or a definition, or a description; and

(b) That the author has applied the principles of binary nomenclature.

(c) *But no generic name nor specific name published after December 31, 1930, shall have any status of availability (hence, also, of validity) under the rules, unless and until it is published either—*

(1) *With a summary of characters (seu diagnosis; seu definition; seu condensed description) which differentiate or distinguish the genus or the species from other genera or species;*

(2) *Or with a definite bibliographic reference to such summary of characters (seu diagnosis; seu definition; seu condensed description). And further—*

(3) *In the case of a generic name, with the definite unambiguous designation of the type species (seu genotype; seu autogenotype; seu orthotype).*

The purpose of this amendment is to inhibit two of the most important factors which heretofore have produced confusion in scientific names. The date January 1, 1931, was selected (instead of making the amendment immediately effective) in order to give authors ample opportunity to accommodate themselves to the new rule.

The Commission unanimously adopted the following resolution:

(a) It is requested that an author who publishes a name as new shall definitely state that it is new, that this be stated in only one (i. e., in the first) publication, and that the date of publication be not added to the name in its first publication.

(b) It is requested that an author who *quotes* a generic name, or a specific names, or a subspecific name shall add at least once the author and year of publication of the quoted name or a full bibliographic reference.

The foregoing resolution was adopted in order to inhibit the confusion which has frequently resulted from the fact that authors have occasionally published a given name as "new" in two to five or more different articles of different dates—up to five years in exceptional cases.

# SOCIETY PROCEEDINGS

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## AMERICAN SOCIETY OF PARASITOLOGISTS

The spring meeting of the Council was held in Washington on March 16, 1929. A number of matters of general interest were discussed. The Secretary's report on the status of membership showed a total of 551 members of whom 425 are residents of the United States and 126 of foreign countries. The financial report of the Treasurer for 1928 showed a deficit of \$2.40. With quite a large percentage of the 1929 dues already paid the funds on hand amounted to \$321.10. The accounts of the Treasurer were audited and found to be correct. Dr. Henry B. Ward was elected as the representative of the Society on the Council of the A. A. A. S. for 1929. It was unanimously voted to hold the next annual meeting of the Society at Des Moines, Iowa, from December 27 to 31, 1929, at the time of the meeting of the A. A. A. S. The following program committee was elected: W. W. Cort, chairman, M. C. Hall and N. R. Stoll. In the discussion of the program for this meeting it was suggested that matters relating to agriculture be stressed. In line with this policy a symposium on Veterinary Parasitology is being planned under the direction of M. C. Hall. In view of the large number of papers being contributed it was suggested that members present papers whenever possible by demonstrations and make their presentations as brief as possible.

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## PROCEEDINGS OF THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON

### *One Hundred Sixteenth to One Hundred Twentieth Meeting*

The one hundred sixteenth meeting was held December 15, 1928.

The following corresponding members were elected: (Foreign) Prof. M. Khalil, Prof. F. J. Meggit, and Dr. Heinrich Micoletzky; (American) Dr. L. R. Cleveland.

Dr. I. N. Filipjev presented the following:

*Classification of freeliving Nematoda and relations to parasitic forms.*—The freeliving forms are regarded as more primitive than the parasitic, owing to: (1) they exceed the latter in numbers of species; (2) more primitive physiology of freeliving, especially marine, forms with cuticula permeable to water, whereas that of parasitic forms and saprozoic Anguillulata is completely impermeable to most substances; (3) more complex differentiation of the cervical gland or renette in parasites; (4) frequently occurring cell constance in parasites, a secondary neotenic character. The class is not divisible into two subclasses because of wide morphological differentiation of both groups.

Order Enoplata with smooth cuticula, absence of esophageal bulb, pocket-form amphids, and reflexed ovaries. Family Enoplidae has esophagus adherent to cuticula anteriorly and cuticula doubled in this region, except in forms with large mouth capsule where adherence is lost but duplication conserved; usually one or two preanal organs. Family Trilobidae cuticula thickened anteriorly but not adherent to esophagus; Trilobinae (freshwater) and Tripyloidinae (marine) included here. Family Dorylaimidae with typical esophagus, narrow before, broad behind; sometimes with spear, Family Mermithidae (according to Steiner) offshoot of Dorylaimidae.

Order Chromadorata with striated cuticula, mostly typical sharpened tail, spiral amphids and reflexed ovaries; esophageal bulb common. Family Plectidae with unfolded mouth capsule, anterior thickening of cuticula as found in Trilobidae; subfamilies Camacolaiminae Micoletzky and Plectinae Micoletzky. Family Chromadoridae with twelve folded vestibulum and generally dorsal tooth; both lost in some specialized forms.



Order Desmoscolecata, peculiar marine forms with huge secreted cuticular rings or bristles; families Desmoscolecidae and Greeffellidae.

Order Monhysterata with extended ovaries and chitinous ring in mouth capsule supporting esophagus. Family Linhomoeidae with double, backward pointing gubernaculum, strongly curved spicula, and soft, thin cuticula. Family Monhysteridae with different spicula.

Order Anguillulata, simplified meromyaria, cuticula impermeable, cervical gland complex. Often middle preneural esophageal bulb. Family Anguillulidae, freeliving, spearless forms. Family Tylenchidae, spear bearing forms, with Sphaerulariinae in body cavity of insects. Strongylidae is considered as a third family owing chiefly to the resemblance of the larvae.

Orders Oxyurata, Ascaridata, Spirurata, Filariata, Diectophymata, and Trichurata are considered separate as by Yorke and Maplestone.

The one hundred seventeenth meeting was held January 19, 1929.

Mr. B. G. Chitwood presented the following notes on the copulatory sac of *Rhabditis strongyloides* Schneider. Fertilized females found in cultures have a large, nearly transparent, mass at the vulva; the copulatory saccus (*cop. sac*). It has none of the yellow color noted in similar structures found on *Cephalobus*, *Acrobeles* and other nemas. It does not come off but persists throughout egg laying. During copulation the male excretes the material and it hardens, cementing to the cuticula of the female everywhere except at the vulva. This cementum holds or furnishes a hold for the male so that he may remain attached as long as eighteen hours during which time the female is dragging him over the plate. At intervals he will insert his spicula for a few minutes, only to withdraw and to reinsert them later. The hardening of the cement leaves a hole, the punctum (*punct*), through which the spicula move. When the eggs (*ov*) are laid they are forced into this mass, stretching it and actually forming a sack, the cavity of which was formerly the hole through which the spicula moved. Another egg may force the first one out but two or three may be seen in the copulatory sac. If the opening is large they may fall out, but if small another egg may force the earlier one out.

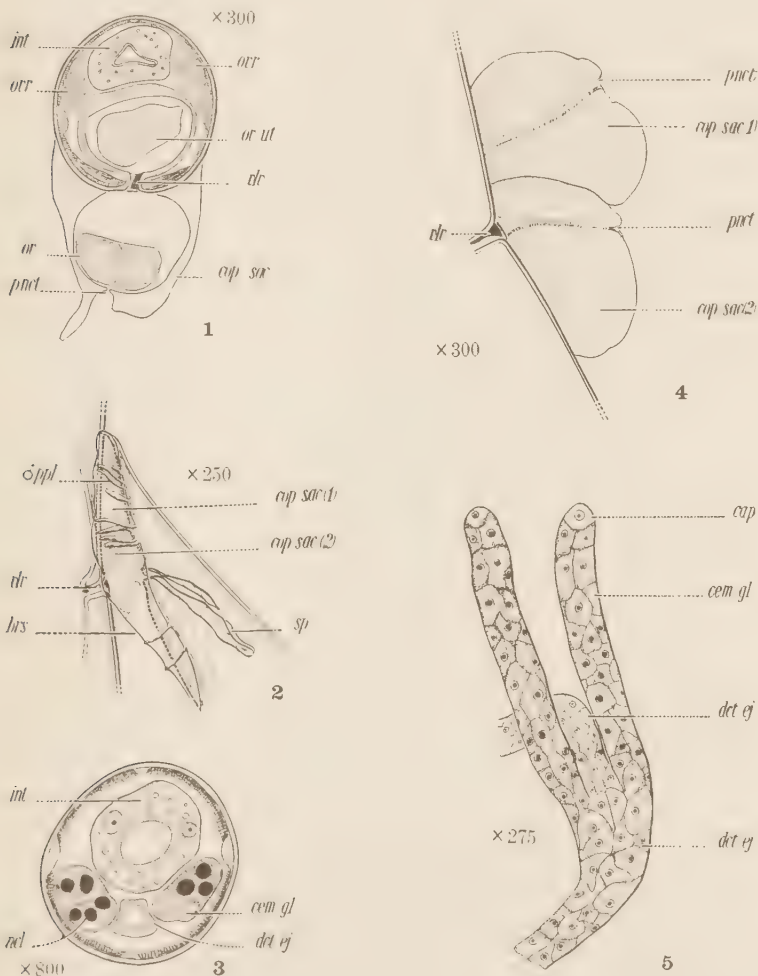
One such structure does not necessarily prevent further copulation; the male surmounts this difficulty by either redissolving a portion of the first sac (2) or by digging under the earlier sac, using his tail as a wedge. The latter method seems to be the most common. The average adult female has two copulatory sacs though three are not uncommon and four have been seen. Multiple sacs do not always mean several successful copulations but when the male is able to insert his spicula, as fig. 4 would indicate, success seems probable.

The organs by means of which the male is thought to secrete the cementum are large cylindrical glands attached to the ejaculatory duct a short distance from the opening into the cloaca, being approximately 15 per cent of the length of the body (135 $\mu$ ). They are transparent, light gray in life. They may be mashed out of the body, however, and be fixed and stained. Hematoxylin-eosin-lichtgrün brings their structure out quite well (5). The gland begins anteriorly with a large cap cell followed by a pair of cells, then it has three cells on each side. This may be seen more clearly in cross section (3). The lumen extends to the cap cell. The thickness of the cells varies with the condition of the gland, but as a rule they are extremely blunt pyramidal cells. The two glands empty into the ejaculatory duct separately.

Mr. J. R. Christie reported finding, in the intestine of a mole cricket, *Gryllotalpa hexadactyla*, a male specimen of *Hoplolaimus coronatus* Cobb. While this root infesting nema exhibited no movement, it was in excellent condition when examined under high magnification and had every appearance of being alive. It had evidently been recently swallowed by the feeding insect. One studying the parasites of insects must be on guard against confusion which might arise through incidents of this kind.

Dr. N. A. Cobb presented papers under five titles as follows:

1. *The Stem-nema Tylenchus dipsaci, its Movement in Commerce, and its Reaction to Hydrocyanic Acid Gas.*—Attention is called to the interception by Plant Quarantine inspectors of two interesting cases of *Tylenchus dipsaci*,—(1) on cut flowers of narcissus arriving from Canada; and (2) from onions imported



1. Trans-sec. through region of vulva; 2. Male attached to female, showing first and second copulatory saccus; 3. Trans-sec. of male through cement glands; 4. Vulval region of female showing two copulatory sacs; 5. Cement glands and ejaculatory duct mashed out.

from Holland. It had been supposed there was not much chance of the introduction of *Tylenchus dipsaci* on cut flowers of narcissus, and their importation has not been prohibited. It is reasonable to suppose that the *Tylenchus dipsaci* in the Dutch onions would belong to a race that could infest onions in the United States. Up to the present time there have been no reports of serious loss due to *Tylenchus*

*dipsaci* attacking the onion in this country. Such losses have occurred, however, in various other parts of the world. Attention was called to a case of this sort occurring in Australia, where the disease must have been introduced from abroad.

The following is the present known geographical distribution of *Tylenchus dipsaci* in the United States, alluding to new localities where this nema has been found since 1925,—toward one hundred in number,—distributed in the States of:

California	Kansas	New York	South Carolina
Connecticut	Maryland	North Carolina	Texas
District of Columbia	Massachusetts	Ohio	Virginia
Florida	Michigan	Oklahoma	Washington
Illinois	New Jersey	Pennsylvania	

This nema is known to have occurred in seven other states;—twenty-six states in all, and about two hundred fifty localities.

Fumigation of infested narcissus bulbs with hydrocyanic acid gas of a strength that destroys the insects infesting the bulbs does not destroy the contained *Tylenchus dipsaci*. *Tylenchus*-infested bulbs from Long Island after being fumigated (*vide* G. W. R. Davidson) yielded *Tylenchus dipsaci* apparently in good condition. A bulb from the same lot was fumigated a second time with a view to ascertain whether a second fumigation would prove fatal. The results were negative. The nemas came through the second fumigation with little, if any, apparent injury.

2. *The Nemic Genus Sphaerolaimus Bastian Composed of Carnivorous Forms.*—Descriptions of 28 (14 unpublished, new) species of *Sphaerolaimus* Bastian, show that the sphaerolaims are cosmopolitan, since the new and undescribed species come from various places on the Atlantic Coast of the United States from the Bay of Fundy to Florida; Jamaica; the Pacific Coast of North America from Costa Rica to California; from New Caledonia; and from Larat, East Indies. For the most part the sphaerolaims inhabit marine mud and sand. They are known to me from depths as great as 20 meters. The 28 species give the average dimensions:

2.2	10.	22.	36	—66.	88.	2.4	10.2	23.4	—M—	88.5
					1.8 mm.					1.6 mm.
2.4	3.6/	4.	4.5	2.9	2.3	3.7/	4.1	4.3	3.2	

The sphaerolaims constitute a *homogeneous group of predatory nemas*, a considerable number of which prey upon other nemas.

The six, non-muscular, thin lips close over the capacious and muscular pharynx, the cavity of which may be divided into three zones, (1) a longitudinally folded and hence apparently longitudinally striated vestibular zone immediately behind the lips; (2) a median, broad, equatorial, slightly convex zone supported and strengthened behind by an encircling series of refractive elements, somewhat movable, joined end to end; and (3) a posterior narrowing zone connecting the middle zone with the simple muscular esophagus. The equatorial, and sometimes, to a certain extent, the posterior, zone is armed internally with numerous, acute, inward, and slightly backward-pointing denticles (see fig.). The wall of the pharynx is thick and more or less opaque, and this probably is why these denticles have hitherto escaped notice. The cells composing the intestine are abundantly supplied with birefringents.

3. *Nemas of the Genus Dorylaimus Attacking the Eggs of Mites.*—Two dorylaims, one of them probably *Dorylaimus carteri*, were observed in narcissus bulbs infested with the mite *Rhizoglyphus hyacinthi*. With the mites was an abundance of their eggs. The dorylaims were observed attacking the eggs.

4. *Characteristics of Carnivorous Free-living Nemas, Including Predators.*—(1) Agility and superior size. (2) Lack of eyespots. (3) Possibly, increased fecundity. 4. Fine striation of the cuticula. 5. Head well armed with papillae.

(6) Pharynx with acute clutching organs,—onchia or denticles. (7) Powerful deglutition through a highly muscular, expansile, but simple, non-bulbous esophagus. 8. Complexity of the intestine; i. e., its wall presenting cells of different kinds, at least some of them likely to contain birefringent bodies. (9) Reduction in size of the renette; possibly its obsolescence or disappearance. 10. Strongly developed esophageal, or salivary glands emptying into the pharynx. (11) Highly developed nervous system; well developed amphids and sensillas.

The following free-living nemic genera are known from definite observation to contain carnivorous species. Two of the genera are included on the basis of the observations of another observer, Filipjev. On the basis of structure, twice as many other genera may reasonably be suspected to be carnivorous. 1. Cheironchus. 2. Cobbionema. 3. Demonema. 4. Dignathonema. 5. Dorylaimus. 6. Enoploides. 7. Enoplolaimus. 8. Eurystomina. 9. Halichoanolaimus. 10. Mononchus. 11. Nygolaimus. 12. Selachinema. 13. Sphaerolaimus. 14. Synonchium. 15. Tricontus (Enoplus). 16. Tripyla.

5. *Amphids of the Mackerel Nema*.—On the front of the head of *Contracacum pedum*, a nemic parasite of the alimentary canal of the mackerel (*Scomber scombrus*), are amphids of small size, but typical form, occurring practically in the same circlet with the four submedian papillae. (See fig. 6.)



Fig. 6.—Front view of the head end of *Contracacum pedum*. *lb dsl*, dorsal lip; *amph*, amphid; *ph*, pharynx; *lb subm*, one of the two submedian lips; *ppl lb*, one of the four submedian labial papillae; *nrv*, nerves (1) of the amphid, (2) of the submedian papilla. Note the interlocking of the lips and the folding of the submedian ones over the dorsal. This feature no doubt gives the nema a powerful labial grip.

Dr. C. H. Barlow, discussing recent experiences in China, pointed out the prevalence of Fasciolopsiasis in the Hangchau region, and the possibility of cleaning up this territory at relatively small cost. Inability to secure the necessary funds and cooperation through lack of local interest has rendered it impossible to proceed with the project.

Dr. E. B. Cram presented a note on the life history of the gizzard worm of ruffed grouse and bobwhite quail. The nematode, *Cheilospirura spinosa*, which occurs under the lining of the gizzard of ruffed grouse (*Bonasa umbellus*) and bobwhite quail (*Colinus virginianus*) has been developed in the grasshopper (*Melanoplus femurrubrum*) as intermediate host, encysted third stage larvae which were recovered from the connective tissue of the body cavity and from the muscles of the legs of an experimentally fed grasshopper having proved infective to a young quail. Seven adult male specimens of the nematode were experimentally produced in this way in the quail. The feeding experiments on other insects, including crickets (Gryllidae), cockroaches (Blattidae) and several species of ground beetles (Coleoptera), have so far been negative. Until recently cockroaches were the only members of the Orthoptera reported as intermediate

hosts for nematodes; Christie, however, has described a larval spirurid, *Agamospirura melanopli*, found in a natural infection of *Melanoplus femurrubrum*. A comparison of the encysted larval stage of *Cheilospirura spinosa* with Christie's description shows the two species to be distinct. Recent observations by Christie to the effect that male specimens of *Mermis subnigrescens* are produced in heavy experimental infections, female specimens in light infections may throw light on the exclusive development of male specimens of *Cheilospirura spinosa* in the quail in this life history experiment. In the case of heteroxenous nematodes, such as the spirurids which pass the larval stages of their life in a secondary host, usually an arthropod, the sex of the nematodes would presumably be determined in the secondary host. Therefore, the fact that the grasshopper was very heavily infected with the encysted third stage larvae may account for the sex of the adult parasites in the quail.

Mr. Oliver R. McCoy reported on the life history of a marine allocreadine trematode, *Hamacreadium mutabile* Linton, 1910, and a marine lophocercous cercaria, *Cercaria floridensis* sp. nov. (Carnegie Institute Year Book, No. 27, p. 280-284).

Dr. Benjamin Schwartz presented the following note on an outbreak of cysticercosis in cattle in Montana.—Recently 97 out of 125 cattle which had been fed on beet leaves and pulp on a ranch in Missoula County, Montana, 7 miles west of the City of Missoula, were found to be infested with *Cysticercus bovis* at an abattoir in Spokane, Washington, where the animals were slaughtered. Following the report made by the Bureau of Animal Industry inspector at Spokane concerning the post-mortem findings, an investigation was made on the ranch and the source of the infestation was traced to a Mexican family of beet growers, the members of which were found to be infested with *Taenia saginata*, as determined by the County Health Office. An investigation of the possible spread of the eggs and proglottids on the ranch disclosed the fact that the waste irrigation water passes underneath an outside toilet used by the Mexican family and then spreads over a large slough from which the cattle drink.

Dr. Schwartz also called attention to a recent report of the Department of Commerce which shows that infestation with tapeworms is present in nearly all Ethiopians. According to the report, the natives use a severe but effective vermifuge made from the powdered blossom of the African kosso tree. The flower is a brilliant red and is plucked when it turns brown, and is then crushed and mixed with water or native beer. The report states that a German vermifuge called "kosso" for its advertising value, has been found to contain male fern extract.

Dr. Schwartz proposed the combinations *Anoplostrongylus paradoxus* (Travassos, 1918) and *A. tipula* (Van Beneden, 1873) and stated that Dr. Albert Hassall called his attention to the fact that these combinations had not been made despite the fact that Boulenger (1926) assigned these species to the genus *Anoplostrongylus* which he proposed on the basis of *Histiostrongylus paradoxus* Travassos, 1918. Boulenger's genus was accepted by Schwartz, 1927, who added to it a third species, *A. delicatus*, without, however, using the names *A. paradoxus* and *A. tipula*, the former being the type species.

Dr. Benjamin Schwartz presented the following note by himself and Mr. Joseph E. Alicata on the occurrence of *Stephanurus dentatus* in cattle. Up to the present time only two records of the occurrence of *Stephanurus dentatus* in cattle have been published, both reports having been made to the Helminthological Society by Hall (1921, 1922). Recently, Dr. B. Strickler, B. A. I., inspector in charge at Atlanta, Ga., has forwarded to the Zoological Division a number of specimens of kidney worms and diseased tissues showing lesions of the parasites, collected in Atlanta.

The largest specimen of *Stephanurus* found in these collections measured 33 mm. in length and 1.3 mm. in width. Other measurements are as follows: 28 by 1.1 mm.; 17 by 1 mm.; 14 by 1 mm.; the latter being the smallest specimen in the collection received from Atlanta. The worms are immature, no eggs being present in the uteri.



Dr. J. A. Scott reported on the action of various killing and fixing methods on hookworm larvae, *Ancylostoma caninum*, as effecting measurement.

Dr. D. Sinitsin reported an intermediate host for *Plagiorhynchus formosus* Van Cleave. In one of several pill bugs, *Armadillidium vulgare*, that were collected near the Chesapeake and Ohio Canal in the vicinity of Washington, D. C., was found an *Echinorhynchus* larva which, after examination, was identified as a young *Plagiorhynchus formosus* from birds. The worm was rather large, 4 mm. in length, including a proboscis.

The one hundred eighteenth meeting was held February 16, 1929.

It is with deep regret that the Helminthological Society of Washington records in its Minutes the death of one of its members, Dr. Joseph Goldberger. Born in Girold, Hungary, July 15, 1874; graduated in 1895 at Bellevue Hospital Medical College with the degree of M.D.; served in the grades of Assistant Surgeon, Passed Assistant Surgeon, and Surgeon, U. S. Public Health Service, 1899 to 1929; died January 17, 1929. Internist, bacteriologist, epidemiologist, helminthologist, author, colleague, and friend. Mankind owes to him a debt of gratitude, especially because of his epoch-making studies on the cause, treatment, and prevention of pellagra.

To the individual members of Doctor Goldberger's family, this Society extends its deep sympathy; with this is coupled the comforting thought that the influence of his life permeates numerous homes, especially in the rural and cotton-mill population of our southern states, where thousands of men, women, and children owe to him improved health, better living conditions, and a happier and longer life.

The following were elected to serve as a committee of trustees of the Ransom Memorial Fund: Dr. W. W. Cort, Dr. Benjamin Schwartz, Mr. J. R. Christie.

Mr. Joseph E. Alicata presented the following note:

*The occurrence of Dirofilaria scapiceps in rabbits.*—Up to the present time four cases of the occurrence of *Dirofilaria scapiceps* in rabbits have been reported; two cases from the Leidy collection, the worms having been found under the skin; the locality is not given but according to Hall the worms are probably from Pennsylvania; at any rate from the United States. Two other cases were reported by Hall. One case is based on a collection by Stiles and Hassall from *Lepus campestris*; the locality is not given. The other case is based on a collection by Douthitt in 1910 from *Sylvilagus floridanus alacer* at Sulphur, Oklahoma. The parasites in this case were found under the skin in the lumbar region. A previously unreported case is based on a collection made by Buchanan in 1916 from *Sylvilagus floridanus mallurus* at Woodford, Va. The parasites, which have been deposited in the B. A. I. Helminthological Collection, were located inside the tarsus of the host. Recently still another case has come to light. On January 20, 1929, Dr. F. B. McCallum forwarded to the Zoological Division of the Bureau of Animal Industry a fore and a hind leg of a rabbit (probably *Sylvilagus palustris*) from Kinston, N. C., with a request for determination of the worms present. Dr. McCallum stated that several farmers said that nearly all rabbits in that locality were infected with this worm this season. Upon examination, six worms (three males and three females) were found inside the tarsus. The worms were found to be *Dirofilaria scapiceps*. No parasites were found in the fore-leg.

Dr. Paul Bartsch called attention to the importance of efforts to be made by the Zoological Division, U. S. Bureau of Animal Industry, when securing hosts of trematode parasites, to determine the hydrogen ion concentration of the water from which the snails are collected. Certain snails live only in water of an alkaline reaction, and others in an acid environment and only a slight change is necessary to cause their extermination. This may offer a means of control without the destruction of aquatic life from wholesale application of copper sulphate.

Mr. B. G. Chitwood presented a note on intravital staining of the amphids and phasmids of *Rhabditis tenuicaudata* (to be published elsewhere).

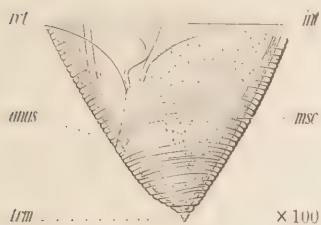
Dr. N. A. Cobb presented the following: *Cerascaris collare* n. g., n. sp., A New Parasite of the Caribbean Fish, *Gobiomorus maculatus*.

$\frac{0.13}{0.5}$   $\frac{1.7}{1.4}$   $\frac{10.6}{2.5}$   $\frac{JUV}{4}$   $\frac{99.7}{0.69}$   $21.2_{mm}$  are the measurements of one of the largest of the specimens. The six specimens available for examination, all of about the same size, are too young to furnish data as to sex. The rather thin layers of the transparent, colorless, naked cuticula are traversed by very obvious transverse striae, especially near the head in front of the nerve-ring, giving rise there to a fine but manifestly crenate contour. In this *special region* only (*collare*), the striae are interrupted laterally, and between the more obvious striae there are much fainter subordinate striae. For some little distance behind the lip region, the main annules are about half as wide as the distance between the striae. Farther back, however, the annules are narrower, not so refractive and by no means readily visible, and the crenations of the contour less pronounced; in fact they are very faint; still farther back the number of subordinate striae increases, that is to say between the more pronounced striae there may be as many as three subordinate striae; this is along through the middle of the neck. Farther back yet the striae, at least as viewed in lacto-phenol, become much narrower and there is a good deal of anastomosing, and underneath them lie very much finer but quite distinct longitudinal striae, very close together, doubtless due to minute longitudinal elements connected with the cells of the musculature. These fine striae, however, are not the contour marks indicating the muscle cells themselves; these latter are seen to be of the character usually connected with the excessively long spindle-shaped" contours of the somatic muscle cells. Not far in front of the tail the contour presents a duplex crenation, or a compound crenation running up to three subdivisions. A single crenation may alternate with a double and a triple. Through the middle of the body there is a distinct, lateral subcuticular, longitudinal element which, though apparently reminiscent of a wing structure, is really an optical effect due to the juxtaposition of the two equal separate parts of the lateral chord (see fig.). Very much more prominent than the four submedian labial papillae is the single, somewhat refractive, unpaired, ventrad, conoid affair, very near the mouth opening, about as high as the distance between two of the main striae a little distance behind the lip region. This is the colorless, conoid, blunt, and apically refractive, non-innervated ventral "horn," from which the form takes its generic name. The renette duct leads directly backward to a long renette attached to the left lateral chord for half its length, as in some other ascarids, and thence continues backward as a duct in the chord itself. There is no very distinct pharynx. There seems to be a very indistinct, oblate, posterior, valveless "swelling" or pseudo bulb, no wider than the remainder of the esophagus, set off by constriction, especially in front, and by small differences in structure. It is doubtful if there is any distinct lumen in the front part of the anterior cecum, though the posterior half of it closely resembles the corrugated part of the intestine nearby. The posterior cecum seems to have no lumen. The intestine, at first irregular, is two-fifth as wide as the base of the neck; for the most part it is of a uniform character and does not have the corrugated appearance characteristic of the anterior portion, i. e., a portion about equaling the neck in length. As seen through the cuticula the lateral chords present fairly definite contours. The lining of the esophagus is a distinct feature throughout its length and finds its main optical expression as a single, zigzag, refractive, very narrow element, apparently located toward the dorsal side instead of exactly in the middle. The nerve-ring surrounds the esophagus rather squarely. From it there can be seen passing, both dorsal and ventrad, nerves of considerable magnitude. As yet no traces of gonads have been seen, even in very well cleared specimens; from which it is inferred that the specimens are still quite young.

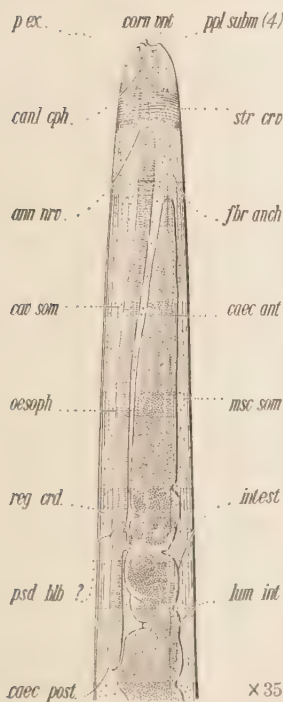
*Cerascaris* n. g. Contracaecum-like with lateral grooves on head, and with ventral oral horn; lips three, simple, connate; pharynx small, simple, unarmed; labial papillae four, submedian; amphids very small and inconspicuous, in same circlet with papillae; excretory pore between ventrally submedian papillae, long narrow renette external to, but attached to left lateral chord to near middle of body; lateral chords well developed, duplex. Type species:

*Cerascaris collare* n. sp. *Cerascaris* with form and dimensions as shown in the illustrations and formula. Only known species.

Dr. W. W. Cort reported a study of the influence of the rainy season on the level of helminth infestations in a Panama village (to appear in *Am. Jour. Hygiene*).



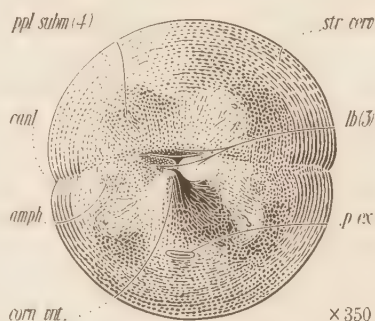
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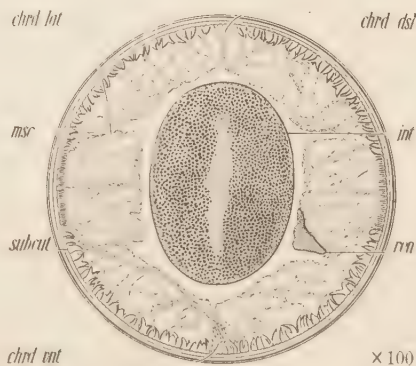
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Five drawings of *Cerascaris collare*. The lettering for the most part is self-explanatory. Fig. 7. Profile view of the tail end. Fig. 8. Profile view of the head end showing the labial horn, *corn vnt* and the cephalic lateral grooves, *canl cph*. Fig. 9. Ventral view of lip region. Fig. 10. Front view of the head showing the labial horn, *corn vnt* and the lateral grooves, *canl*. Fig. 11. Cross section behind the caeca looking backward; showing the left-hand renette, *ren*.

Dr. M. C. Hall discussed the proposed program of field work in the Western United States to be carried out by the Zoological Division, U. S. Bureau of Animal Industry.

Dr. E. W. Price presented three notes as follows:

(1) *Distomulum oregonensis* Ward and Mueller, 1926.

In 1926, Ward and Mueller described a larval trematode which they regarded as the cause of a pop-eye disease of trout fry. In view of the fact that the material upon which the description of *D. oregonensis* was based was obtained in a region where salmon poisoning of dogs was prevalent, the writer conceived the possibility of the identity of this trematode with *Nanophyetus salmincola* Chapin. Specimens of *D. oregonensis* were obtained through the courtesy of Dr. H. B. Ward and comparisons made with the adolesearia of *N. salmincola* which were obtained from Dr. B. T. Simms of Corvallis, Ore. This comparison showed no essential differences and the two forms are regarded as identical. *Distomulum oregonensis*, therefore, falls as a synonym of *Nanophyetus salmincola*.

(2) Acanthocephalid larvae from the esophagus of turkey poults.—Recently Dr. R. L. Rogers of San Angelo, Tex., presented the writer with several specimens of acanthocephalid larvae which had been obtained from the esophagus of a turkey poult. According to Dr. Rogers this parasite occurs beneath the epithelial lining of the esophagus in numbers varying from a few to a hundred or more. About 10 per cent of the birds in the vicinity of San Angelo were reported to be infested. Examination of these larvae show that they belong to the genus *Oncicola* Travassos, the number and morphology of the hooks corresponding closely to those of *O. canis* which is a more or less common parasite of dogs in the Southwest. These larvae are, therefore, regarded by the writer as probably being a larval stage of this species.

(3) *Distomum xenodontis* Cordero and Vogelsang, 1928.—Recently Cordero and Vogelsang (Cuarta reunion Soc. argent. patol. reg. Norte, Buenos Aires, 1928, pp. 636-641) described a trematode from the intestine of a snake, *Xenodon merremi* (Wagler), for which they propose the name *Distomum xenodontis*. Since the genus *Distomum* has only the status of a collective genus and as the authors were unable to place their species generically, the writer proposes to allocate this trematode to the genus *Opisthogenes* Nicoll, 1914. *Opisthogeneris xenodontis* (Cordero and Vogelsang) resembles the genotype, *O. interrogativus*, sufficiently to be considered congeneric.

Mr. L. A. Spindler reported the results of recent field work on human ascarid infestation in certain rural districts in western Virginia.

The one hundred nineteenth meeting was held March 16, 1929.

Dr. C. H. Barlow gave an interesting account of his recent experiences in China while investigating the *Fasciolopsis buski* infestation in the region of Shaohsing.

In discussion, Dr. Stiles pointed out the dangers often involved in treating edematous cases. Dr. Barlow replied that the treatment of such cases had not resulted in circulatory disturbances arising from the sudden reduction of edema.

Dr. Cort called attention to the uniqueness of the situation in the Shaohsing region tending to bring about optimum conditions for the development and spread of this parasite. Discussing practical means of cleaning up this area, Dr. Barlow stated that the snails were quickly killed by lime, even in low dilutions.

Dr. W. A. Hoffman reported the case of a sailor in Haiti, heavily infested with *Giardia*. Bismuth silicate proved an effective remedy.

The one hundred twentieth meeting was held on April 20, 1929, at Dr. Stiles' residence.

Dr. N. A. Cobb presented six short papers as follows:

(1) *Distribution of the Stem Nema in the U. S. A.*—A map exhibited the progressive distribution of *Tylenchus dipsaci* in the United States up to 1929.



Between 1926 and 1929 a considerably increased number of stations became known in which the stem nema is attacking not only narcissus but alfalfa and clover. The principal increases are in regions already known to have carried the stem nema, and particularly where narcissus plantings are known to be not uncommon.

(2) *Syngonism in Oxyurids*.—Drawings are presented showing the proportions of the different parts of the gonads of oxyurids from millipedes, when these oxyurids,—that is, their female forms,—are syngonic. Attention is again called to the very great disproportion in size between syngonic sperms and those to be expected in sperms derived from normal males.

(3) *Stratigraphic Distribution of Nemas in Marine Sand*.—(To be published elsewhere.)

(4) *The Locomotion of Draconema*.—(To be published elsewhere.)

(5) *Hotwater Treatment of Root Gall*.—In a joint investigation, carried on by the Plant Quarantine Station at Washington, in charge of Mr. Peter Bisset, and the writer, it was shown that when plants belonging to 16 widely different orders of phanerogams were treated with hot water at temperatures varying between 116° and 122°F. and for times varying from 10 to 30 minutes, *Caconema radiculicola*, known to be in the roots before they were treated, was apparently exterminated, while the plants survived, generally with comparatively slight injury and afterwards grew well in the greenhouse.

(6) *Notes on methods of combating the stem nema, Tylenchus dipsaci*.—Clover seed from such infested areas in Idaho carried over 500 nemas to the pound, about 90% of the specimens being *Tylenchus dipsaci*. These nemas adhered in a desiccated but living condition to the surface of the seed. When the seed was re-cleaned,—that is, cleaned again after the ordinary cleaning,—the number of nemas was very much reduced, and when re-cleaned a second time the nemas were reduced to about one *Tylenchus dipsaci* to the pound of seed.

When such "contaminated" clover seed is treated with hot water for 15 minutes at about 118°F., all the *Tylenchus dipsaci* are killed. At the same time the germinating quality of the red clover seed is increased, provided the seed be sown as soon as possible after the treatment,—that is to say, as soon as the seed is dry enough to admit of proper manipulation in sowing, either by hand or in a drill.

Red clover seed grown under Oregon conditions, when treated as already described for Idaho, gives practically the same results,—that is to say, (1) re-re-cleaning the seed removes very nearly all the nemas; (2) treatment with hot water at 118°F. for 15 minutes kills the nemas and at the same time increases the viability of the seed.

An estimate, made by Dr. G. H. Godfrey showed as many as 400 nemas per gallon in irrigation water; this was on areas the crops of which were infested by nemas. It will readily be seen what a very efficient method of spreading these diseases is furnished by irrigation water, and that the distribution of irrigation should receive careful attention with reference to this matter.

Dr. C. W. Stiles and Mr. Benjamin Collins presented the following note on the longevity of Cimex. Associate Medical Purveyor C. H. Bierman, U. S. P. H. S., Perry Point, Md., reported that in Jan., 1925, a contract was made with a Baltimore, Md., laundry for the bleaching of several thousand sheets. Specifications required contractor, after bleaching sheets, to wrap same in bundles of one dozen each, and pack in wooden cases, 24 dozen to the case. The bundles of a dozen each were wrapped in heavy wrapping paper and fastened with gummed paper tape. The wooden cases to contain 24 dozen each were of the usual wood packing case type. Completion of contract was effected in June, 1925, at the end of which time all sheets were returned to the Depot and stored in one of the warehouses, which is without heat. Some of these sheets were unpacked in March, 1927, after one year and nine months of storage and in one case four live bedbugs and one dead bedbug were found in the folded sheets.

In looking up various records we have located one which states that live bedbugs have been found "up to 14 months." Bierman's report raises the period up



to 21 months. Dr. Bierman's specimens were not identified by any entomologist and the question naturally arises whether the specimens in question were from birds, bats, rodents or other animals for which *Cimex* has been reported. Circumstantial evidence indicates that the species in questions were true bedbugs, but strictly speaking it is conceivable that they might have belonged to some other species. A bat or a swallow might have entered the laundry building, but the mathematical probabilities are that the insects were brought in on soiled laundry.

Dr. E. B. Cram presented the following notes:

*A species of Strongyloides from the ceca of chickens.*—In chickens originating from Louisiana, specimens of *Strongyloides* occur which will be described elsewhere as a new species.

*The life history of Tetrameres americana (Cram, 1927) Baylis, 1929, a spirurid of the proventriculus of chickens.*—The complete life cycle of this nematode has recently been demonstrated experimentally, with the grasshopper, *Melanoplus differentialis*, as the intermediate host. Grasshoppers, laboratory reared, were fed eggs of the nematode, which had been removed from the glands of the proventriculus of a chicken. On dissection of two of the grasshoppers, one of which died on the seventh day and the other on the ninth day following the feeding, there were found large numbers of spirurid larvae, unencysted. A third grasshopper which died 42 days after the feeding, but which unfortunately was not examined until two days after its death, contained large numbers of larvae which apparently had excysted and died after the death of the insect, and also a few loosely encysted larvae, in the muscles of the legs, the head and the body proper. The larvae, 1.8 mm. long, bore at the tail end a circle of 12 papillae. Specimens of these larvae were fed to a 70-day old chicken; in the proventriculus of the chicken when it was killed 35 days later, was found one female specimen of *Tetrameres americana*. Larvae from another grasshopper, killed 54 days after the feeding of the nematode eggs, were fed to two chicks which had been hatched only two days previously. Twenty-three days later, from the proventriculus of one chick, which appeared very sickly and was, therefore, killed, were collected 14 female and 5 male specimens of *T. americana*, from the other chick which died 25 days after feeding of the larvae, were collected 7 female and 5 male specimens of *T. americana*. The nematodes from both chicks appeared to be adult, but the eggs of the female were not embryonated. The life history of the European form, *Tetrameres fissispina* from chickens has previously been described as involving *Daphnia pulex* and *Gammarus pulex* as intermediate hosts.

Dr. M. C. Hall exhibited an instrument devised for the removal of oxwarbles by suction. The instrument is reported to work satisfactorily.

Dr. John Harper, U. S. Navy, reported a case of Japanese schistosomiasis in an enlisted man in the U. S. Naval Service in which the diagnosis was made following an appendectomy. The disease was contracted eight years ago at Ichang, China. There was no history of symptoms of the first stage, i. e., urticaria, fever, etc. (Details to be published in the U. S. Naval Medical Bulletin, October, 1929.)

Dr. N. Hamilton Fairley, London School of Tropical Medicine, discussed the case of schistosomiasis presented by Dr. Harper, particularly the clinical value of his complement fixation and intradermal tests in the diagnosis of human schistosome diseases in general.

Dr. N. R. Stoll reported briefly on later *Haemonchus* studies. Recalling that his earlier report to the Society (Jour. Parasit., 15: 217) had indicated that "perhaps certain special conditions" were responsible for the resistance acquired by the sheep hosts, he showed that the most important of such possibilities, namely, a worm strain not typically pathogenic, could not be longer held the responsible factor, inasmuch as in a 1928 experiment the worms used were shown to be able to produce a fatal effect in sheep under natural reinfection conditions. The identical experiment in which a sheep died from a "fulminating" infection on an out-of-doors plot, also permitted a non-resistant animal to undergo the selfcure crisis, and the animal, with another carried through the resistant stage in an indoor

experiment, were then protected from any considerable further infestation. It was also brought out that the experiments had demonstrated a fundamental analogy with certain types of bacterial infections, as typhoid, in that sheep hosts of *Haemonchus* developed one of three types of response to the worms: "fulminating" fatal infections; self-curative and protective phenomena (which might or might not involve complete disinfestation but which would produce significant protective effects); or, in the absence of sufficient reinfection, chronic infestations in which the worms tended to live out their "normal" life histories undisturbed.

J. R. CHRISTIE, *Secretary*.

## BOOK REVIEWS

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ANIMAL PARASITOLOGY. WITH SPECIAL REFERENCE TO MAN AND DOMESTICATED ANIMALS. By ROBERT HEGNER; FRANCIS M. ROOT, and DONALD L. AUGUSTINE. 731 pp., 280 figs. The Century Company, New York. 1929.

A recent important addition to the text books in this field is that in the Century Biological Series. As a matter of fact this is really three books in one and presents the important advantage of treatment in separate fields by those who are recognized as leaders. The subject of parasitology has experienced such tremendous growth within the last quarter century that whatever may have been true previously, it is not possible today for any one man to write with equal authority on different parts of the field. The introduction and the section on Protozoology have been written by Professor Hegner of Johns Hopkins whose extensive work in this field is too well known to need comment. The introduction on parasitism in animals deals very briefly with some of the main phases of this abundant and varied condition. The author has doubtless felt himself constrained by the limitations of space and presents in the utmost brevity these important biological considerations. In view of his interesting general discussions on host-parasite relations that have been printed elsewhere it seems unfortunate that he could not have done more here to present topics which are so well calculated to arouse the interest of the student and to broaden his conception of the importance of this field.

The section on protozoa is fortunately condensed in that portion which deals with the taxonomy of the group and the descriptions of the various types are well supplied with the biological information that is interesting to the student and important in gaining an adequate conception of living organisms. In new species one finds a historical record most concisely presented and an outline of the structure, life cycle, methods of transmission, and then in more extended form the pathogenicity and host parasite relations. The author wisely discriminates between the important and reasonably known forms and those doubtful species which have been occasionally reported or are based upon structure or biological features which have not been adequately established. The author's plan deserves special commendation in the addition to each section of some discussion of methods including the collection of material, concentration, preparation for examination and means of cultivating the organisms for laboratory study and experimentation. The students will find many other features of marked value such as the table and discussion for the differential diagnosis of the species occurring in man. The figures which are numerous are mostly good although some of them have not printed well and in consequence appear coarse or muddy. There is, however, a certain lack of balance in some cases between the size of the figure and the amount of detail. In a few instances also, e. g., Figure 43, the engraver's work has not been carefully done so that the effect is marred.

The second section of the work covering Helminthology was written by Doctor Donald L. Augustine of Harvard Medical School. Much the same method of procedure has been followed in handling the different topics. One finds, however, a lack of definite detail in the description of the species that makes accurate determination more difficult even despite the presence of tables which give the contrasting facts utilized in the diagnosis of the different types. The text is well written and complete as well as up to date and the illustrations in the main good although one notes the persistence of a few ancient and honorable illustrations like that of *Fasciola hepatica* which has been replaced in other works by much more recent and adequate illustrations. One wonders why the author should have given two illustrations of *Clinorchis sinensis*. Even if both had been desired for some reason they would have been more valuable if placed side by side on the same page. The section on Schistosomiasis is exceedingly well written and complete. The diagram of a mature tapeworm proglottid (Fig. 116) is in reality one of Leuckart's originals although credited wrongly to authors fifty years later

and the figure illustrating the development of the broad fish tapeworm (Fig. 125) was only rearranged by the authors cited. The author is hardly to blame for these errors which are due to the unfortunate habit of some writers in assuming originality for figures that have been merely redrawn.

The section on medical entomology which is contributed by Professor Francis M. Root of Johns Hopkins is apparently the most condensed part of the book. The complex keys which will prove very valuable for the student or field worker desiring to make an accurate determination of the insects found in the course of his studies, take up a considerable portion of the space, and the descriptions as well as the accompanying discussions have been necessarily reduced to lowest limits in consequence. The illustrations are nearly all original and very well drawn. The sections on control are sure to be of special value and are well illustrated. However, the text is so evidently condensed that it does not afford as attractive reading as the earlier sections of the book. The work closes with an extended bibliography of some sixty pages and two good indices. A number of typographical errors were noted in the examination of the book and unfortunately some of them occurred in scientific names which are likely in consequence to be incorrectly cited. On the whole the work contains so much that is new and valuable and so little to criticize that it will be welcomed by teachers and students in this field.

PROTOZOOLOGY. A MANUAL FOR MEDICAL MEN. By JOHN GORDON THOMSON and ANDREW ROBERTSON. 376 pp., 220 figs., 4 plates. William Wood and Company, New York. 1929.

The book has been prepared primarily for the use of medical men engaged in an interim course of study. Evidently the task is difficult by virtue of the wide variation in the training of such students and in the needs of the particular field in which they are at work. The authors emphasize that the time available is necessarily short and the matter must be presented in the briefest and clearest possible manner. The importance of protozoal parasites is being rapidly recognized more fully so that the structure, biology, and life history demands increasing attention from those charged with control of sanitary measures.

The work starts with a brief general introduction followed by a synopsis of the classification. It then takes up in order the malarial parasites of man in various aspects, the pathology of the disease, blackwater fever, and immunity. Next is a discussion in separate chapters of coccidiosis, piroplasmosis, haemogregarines and gregarinina. This section is followed by chapters on the amoebae and their pathological relations. Next in order come the intestinal flagellates and following them the trypanosomes and leishmanias which are treated from various standpoints in different chapters. Brief chapters are devoted to ciliates, sarcocysts, intracellular bodies and toxoplasmosis. Finally spirochetes and the diseases produced thereby, including rat-bite fever, are considered somewhat more fully. Brief sections on technique, definitions, and references close the book.

The authors state in their preface that the volume is not intended as a comprehensive zoological treatise and that they violate the usual zoological arrangement "for convenience in teaching and in linking up with the clinical work." On such views as this opinions will differ widely. Experienced teachers in the clinical field have felt that the scientific method which incorporates the results of zoological investigations is of great value in developing a sound appreciation of relationships. Students and especially those who take interim courses of this type are not only likely but certain to meet in the field conditions and types not included in any such brief survey. Indeed such men have in the past contributed conspicuously to a knowledge of the subject and to the elucidation of obscure features in previous accounts of many such organisms. Furthermore our knowledge of human parasites would have been barren indeed if zoological studies had not supplied a wealth of comparative material as a basis for elucidating conditions in the relations of human parasites. However, the authors are not only inves-



tigators of standing but prominent members of the staff of the London School of Hygiene and Tropical Medicine which has for many years successfully prosecuted the training of visiting medical men in brief courses. Furthermore their outspoken recognition of the work of Wenyon makes it clear that the attitude they take is not one of narrowness or isolation. In passing one might, however, ask what value their students could possibly find in bare lists printed here of parasitic protozoa found in other animals. As a rule such lists lead workers in outlying territory to identify material they find through identity of hosts and thereby to introduce extensive and unfortunate confusion in the field of parasitology.

The volume is well printed, the color plates are beautifully done and most of the text figures are good. However, some outline drawings are reproduced on a greatly exaggerated scale which gives the impression of crudity and certainly defeats the purpose of the authors in endeavoring to incorporate a maximum amount of material into a limited space. Some cuts even have the coarseness of rough blackboard diagrams and certainly mar the appearance of the book which is otherwise most attractive. Special praise should be given for the incorporation of brief sections on fallacies and puzzles in blood examination, on coprozoic types, on methods of fecal examination and on various types of pseudoparasites. The authors might have made these items more useful if they had been drawn together under a single heading but they have been very well considered in this book. Such topics are commonly passed over even in laboratory texts with the briefest mention, yet the reviewer is sure that most errors of determination are due to lack of familiarity with the microscopic appearance of common objects and consequent misinterpretation in microscopic diagnosis more than perhaps to all other difficulties combined. In emphasizing again and again the ease of misinterpretation and in outlining exact means for differentiating not only between species but also between parasites and other objects that may be encountered, the authors have performed a distinct service for the student. One may also commend highly for practical reasons the incorporation into the text of doubtful structures such as the intracellular bodies and of a considerable series of forms in the group of spirochetes or superficially related to those forms, even though the items mentioned can probably not be justly classified as protozoa.

A MANUAL OF HELMINTHOLOGY, MEDICAL AND VETERINARY. By H. A. BAYLIS. 303 pp., 200 figs., 12 tables. William Wood & Company, New York. 1929.

The appearance of this work by Doctor Baylis of the South Kensington Museum of Natural History is sure to be welcomed since it furnishes the student for the first time with short descriptions of the genera and species of the helminthes found in man and the chief domestic animals. The author expresses the hope that with the aid of the illustrations these may enable the reader to make an approximate determination of the parasitic worms he is likely to meet. He confesses that he does not like keys and yet one is compelled to believe that even though such aids are highly artificial they would have been of service in the use of this book. As the matter stands at present the book contains sixteen unrelated families of trematodes, seven similarly disconnected families of cestodes, and sixteen of nematodes. Only the latter are grouped into orders of which here the author gives five. Even for an advanced student it will be difficult to use without undue delay a text in which the major subdivisions are not in some way tied together or contrasted with each other in a key and the reviewer is of the opinion that students of less maturity will all too frequently attempt to incorporate in the wrong subdivision species under study. It would be especially helpful if the author had indicated the magnification in connection with different figures as has indeed been noted in a few cases. On the whole most of the illustrations are very good and many of them are new and original. In checking the text remarkably few slips were noted although a few seem to have crept in such as the comment on page 10 that the Rat-king *Cercariae* are marine. The author goes to the extreme in omitting all references to literature. He might have compromised here by referring to some other work in which the student would find the necessary



references. However, such helpful suggestions will ordinarily come readily when the work is consulted by those who are working in any institution. Only the isolated worker will be handicapped thereby. The work closes with a valuable index of the parasites of man and the principal domestic animals arranged under their host. A second general index occupies the concluding pages.

MANSON'S TROPICAL DISEASES. A MANUAL OF THE DISEASES OF WARM CLIMATES. By PHILIP H. MANSON-BAHR. Ninth Edition. Revised. With 23 color plates, 12 halftone plates, 401 text figures, 6 maps, and 34 charts. William Wood and Company, New York.

The appearance of the ninth edition of this admirable and highly appreciated work deserves especial attention. The work done by Sir Patrick Manson in the field of parasitology is too well known to need special mention here. It was his knowledge and his experience in the East which enable him to write the first great work on tropical diseases and to accord to animal parasitology its proper place in the etiology of disease in man. The editions of this text which Sir Patrick prepared were storehouses of information on animal parasites and the new edition under consideration here measures up well to the same standard. Even though only a brief time has elapsed since the appearance of the eighth edition it has been necessary to revise a considerable number of items. The topic on yellow fever has been remodeled most conspicuously. Some thirty new figures have been added as well as five new halftone plates and three new colored plates which form most valuable aids for the workers in this field. One notes some revision in the sections on protozoology and laboratory technic. These form a valuable addition to the work. Efforts of both publisher and author to keep this manual thoroughly abreast of progress in the field deserves special commendation and will be highly appreciated by those who are endeavoring to pursue studies in this new and not yet well organized and stabilized territory.

PRACTICAL CLINICAL LABORATORY DIAGNOSIS. By CHARLES C. ROSS and FOSTER M. JOHNS. New third edition. 187 pp., 125 text figs., 14 halftone plates, 6 color plates. William & Wilkins Company, Baltimore, 1929.

The new edition of this valuable laboratory diagnosis has been entirely rewritten and deserves special commendation. It gives in brief form the use and care of the microscope, the methods for blood study, the results under normal condition and the contrasting conditions in malaria. In similar fashion the urine, feces, sputum, etc., are treated. The text is clearly written and the illustrations reasonably good and abundant although one may question whether all of the figures on plate 13 representing photomicrographs of ova and larvae of parasitic worms will justify definite identification of most of the types illustrated. In connection with this study and at some other points it might have been a wise precaution to warn the students regarding the proper method of making final determinations. The book is remarkably adapted for class room instruction and will be recommended in its revised form by many who found it exceedingly useful in the earlier editions.

MORPHOLOGIC VARIATION AND THE RATE OF GROWTH OF BACTERIA. ARTHUR T. HENRICI. Charles C. Thomas, Publisher, Springfield, Ill., and Baltimore, Md., 1928, 194 pp.

Few bacteriologists today hold strictly to a belief in monomorphism of bacteria. Researches by Almquist, Löhnis, Hort, Enderlein, Mellon and others in the past ten years or so, indicate that a new, rational pleomorphism is developing, a pleomorphism quite different from the chaotic, hopeless pleomorphism of earlier days. Modern pleomorphism is an orderly, progressive affair with one form following another in regular sequence. Many hypotheses have been advanced to explain the variations in shape which were forced upon bacteriologists and which could not be

included in the older term involution form of Naegeli. Löhnis reported the existence of life cycles for the bacteria; Hort used the term life-histories; Almquist, Mellon, Enderlein, and others reported data to indicate that bacteria are not the primitive simple organisms so facily taught some thirty years ago. It seems proper to look upon the bacteria as organisms with just as complex cell structures, life histories, etc., as are possessed by some higher organisms.

Prominent among the recent contributions to the newer biology of bacteria, is Henrici's application of Minot's process Cytomorphosis to this group of micro-organisms. Henrici's ideas on this point are presented especially in Chapter X of the monograph under review. Three forms of bacterial cells are recognized in bacterial cultures, embryonic, mature or differentiated, and senescent forms. Henrici believes that cytomorphosis explains the nature of variations in bacterial cells better than does the term life cycle. The question arises why is it necessary to set these phenomena against one another. May not one be superimposed upon the other? Biologists will profit by reading Henrici's monograph. It is further evidence that bacteria are not simple, primitive cells as was once believed.

Under the title of *Recherches sur les Helminthes de L'Afrique Occidentale Française*, has appeared in the *Collection de la Société de Pathologie Exotique* an interesting study by Ch. Joyeux, E. Gendre, J.-G. Baer (Masson et Cie, Paris, 1928). The authors have had opportunity to study an important collection of parasites collected in a region from which only fragmentary information of earlier date is available. The work is largely taxonomic. It includes a description of several new species. It will appeal, however, not only to specialists in helminthology, but also to physicians, veterinarians, and naturalists working in that territory or dealing with collections obtained there.

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#### ERRATA

In Vol. XV, No. 3, p. 224, lines 1 and 5 the name *Vallonia indentata* should read *Vitrea indentata*.

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